A PRACTICE OF ORTHOPÆDIC SURGERY

BY

T. P. McMURRAY

C.B.E., M.B., M.CH., F.R.C.S.(EDIN.).

PROFESSOR OF ORTHOPÆDIC SURGERY LIVERPOOL UNIVERSITY, HONORARY ORTHOPÆDIC SURGEON DAVID LEWIS NORTHERN HOSPITAL, DIRECTOR OF ORTHOPÆDICS ROYAL LIVERPOOL CHILDREN'S HOSPITAL, CONSULTING ORTHOPÆDIC SURGEON LANCASHIRE COUNTY COUNCIL, VISITING ORTHOPÆDIC SURGEON ALDER HEY CHILDREN'S HOSPITAL, LIVERPOOL, CONSULTING SURGEON TO THE MINISTRY OF PENSIONS HOSPITAL, REGIONAL ORTHOPÆDIC CONSULTANT MINISTRY OF HEALTH, ETC.

THIRD EDITION

LONDON

EDWARD ARNOLD & CO.

First published 1937
Second edition 1943
Reprinted 1944, 1945 and 1946
Third edition 1949

BOOK
PRODUCTION
WAR ECONOMY
STANDARD

TO THE MEMORY OF

SIR ROBERT JONES,

THE FATHER OF ORTHOPÆDIC SURGERY

Printed in Great Britain by
Butler & Tanner Ltd., Frome and London

PREFACE
TO THE THIRD EDITION

The advances which have taken place in many branches of orthopædic surgery have necessitated alterations and revisions in several chapters. The fundamental principles have not altered, but the many improvements of technique and methods of investigation have widened the scope and the usefulness of orthopædic practice.

PREFACE

TO THE FIRST EDITION

In the following pages I have endeavoured to give the reader a description of the basic principles which underlie treatment in orthopædic surgery. Details of the many operative procedures which are usually included in the larger text-books have been omitted, the types of treatment described being those which, in my opinion, have given the most consistently satisfactory results

No reference has been made to Fractures, or their treatment, as this subject is such a large and important branch of surgery that it deserves consideration in a separate volume and not simply as an addendum to orthopædic surgery.

In collecting material for this work I have been fortunate to have had considerable assistance from Mr. J. B. Reid and Dr. R. Lunt who contributed many of the drawings, and from Dr. J. H. Mather from whom I obtained many of the X-ray photographs. For the completion of the work I must acknowledge the debt of gratitude I owe to Mr. W. J. Eastwood and to Miss Evershed, whose criticism and stimulation have been invaluable.

CONTENTS

A PRACTICE OF ORTHOPÆDIC SURGERY

CHAPTER I

ORTHOPÆDIC SURGERY

Orthopædic surgery can best be defined as the surgery of the locomotor system embracing the treatment of injury, disease or deformity of the limbs, joints and the spinal column. The derivation of the word orthopædic from *orthos*, "straight," and *paidion*, "a child," indicates that the orthopædic surgeon is primarily concerned with the prevention and correction of deformities in young children. To this limited section of surgery there has gradually been added the treatment of the acute and chronic joint lesions, together with the fractures and dislocations which are such a potential cause of deformity and disability. The outlook of the orthopædic surgeon must not be confined to the consideration of the deformity which follows the cessation of active treatment, but he must visualize the possibility of the greater deformity which may appear as a result of growth.

As orthopædic surgery is so closely concerned with growing and developing tissues the outlook of the surgeon engaged in this branch should be essentially conservative. Operations—such as moulding and manipulation—are to be preferred to the more radical measures which are often more attractive, and this tendency to conservatism should not be discarded even though the simple procedures are sometimes followed by a recurrence of deformity. Extensive bone operations, which must interfere with growth, should be avoided as far as possible in the child, and if such measures are necessary they should always be postponed until this danger has to a large extent disappeared.

Medicine and surgery are essentially interdependent, and tragedies are inevitable if an attempt is made to segregate any one branch and to consider it as a separate water-tight compartment. A particularly good illustration of this interdependence is seen in the very common condition which is loosely described under the title of "Low Back Pain." This complaint of persistent pain and aching in the back cannot for a moment be considered as a clinical entity, but must be recognized as a symptom of underlying disease or mechanical disability. Thus, pain complained of in the lumbar spine and sacro-iliac region may be the result of retroversion of the uterus, endometritis, or some other gynæcological condition, whilst a similar group of symptoms may follow on renal affections, intestinal inflammations, or spinal disabilities. A similar series of symptoms may be caused by errors of posture when the patient

stands with the lumbar spine in a position of excessive lordosis, and with the feet abducted and everted Another equally common example of the necessity for combined study is seen in the treatment of rheumatoid arthritis, where the mechanical treatment of the joint condition, the attempts at correction of the deformity, or the improvement of function come under the direction of the orthopædic surgeon, while the treatment of the causative infection must rest in the hands of the biochemist, pathologist and physician. These common examples illustrate the necessity for the treatment of any patient complaining of indefinite symptoms by the combined skill and knowledge of the practitioners of every branch of medicine. It is because of such considerations that the growth of special hospitals of any type is a regrettable feature of present-day medicine, and a continuation of development along these lines must hamper progress.

EXAMINATION OF A PATIENT

As young children form such a large proportion of the patients dealt with by the orthopædic surgeon, it is essential that all the necessary examinations should be conducted with the greatest possible gentleness. If, during the course of the examination, the child is frightened, the surgeon has failed in his object. The instinctive and widespread muscle spasm, which is present in any crying child, limits or obliterates the movements in a suspected joint. In examining any joint all its movements, both active and passive, must be investigated and recorded, and this examination should be conducted under a planned scheme. The active movements should be examined first, if the patient is a child considerable time may be necessary before the full range is demonstrated. Passive movements should then be noted, and in this examination certain points are of importance. If the surgeon grasps a limb very firmly the patient—especially a young child—instinctively resists and the movements are inhibited. If, however, the limb is held lightly with the fingers, and not with the whole hand, the child's confidence is secured and the full range can be measured accurately.

In an examination of the lower limbs it is always advisable, where possible, to examine the patient both in the recumbent and in the upright position. This latter examination may give an entirely different impression of the conditions present from that obtained whilst the patient is recumbent Examinations of the spine and lower limb can only be considered to be complete when the patient can be seen walking about with the spine, legs and hips uncovered. By this means alteration of stance, tilting of the pelvis, and of the alignment of the spine can be recognized, such deviations from the normal often being obscured when

the patient is recumbent. In making the diagnosis of an orthopædic condition it is usually necessary to carry out many different types of examination, those most commonly employed being described in the following paragraphs.

Measurements. Measurements of the limbs are essential, and must be conducted along recognized lines. Thus, in examining the lower limbs measurements are taken from the anterior superior spine of the ilium to the tip of the internal malleolus of the same side. With legs of equal length and with normal hip joints, these measurements will be equal if, at the time of measurement, the thighs and legs are placed at exactly the same angle to the pelvis on each side. If one thigh is adducted and the other abducted, the distance between the bony points will be increased on the adducted side, and decreased on the opposite side.

This measurement from the anterior superior spine of the ilium to the internal malleolus of the tibia is described as the real length of the limb, in contrast to the measurement taken from the umbilicus to the internal malleolus, which is described as apparent length. This latter measurement varies very greatly, especially when the hip joint is ankylosed. If the ankylosis has occurred with the thigh adducted, the pelvis on the affected side is raised in order that the limb may lie in line with the body. Because of this, the apparent measurement of the ankylosed limb is diminished, whilst the normal limb—which is abducted—is apparently increased in length.

When the ankylosis has occurred in abduction the affected limb is apparently increased in length, whilst the normal side is correspondingly decreased. It is, therefore, essential that the pelvis should be level before measurements are made, and if, on account of ankylosis of one hip joint, it is not possible to bring the pelvis straight, the differences in the real and apparent lengths of the limbs give a clear indication of the amount of pelvic tilting.

Similar rules must be observed in making any other series of measurements; bony structures must always be employed as the fixed points of the examination, and the limbs which are being measured must always be fixed at the same angle with the trunk. This point is well illustrated in the measurements of the upper limbs, where the length is usually calculated from the tip of the acromion to the external condyle of the humerus. If this measurement is taken with the arm adducted, the distance between the bony points is greater than when the arm is abducted to the horizontal plane.

Movements. It is essential that all suspected joints should be examined both for active and passive movements. The patient is asked to move the affected joint, or joints, through the full normal range of movements. Thus, for the spine, flexion, extension, lateral

deviation and rotation are all carried out actively, both in the upright and recumbent positions. If a full range of active movements is present in any joint there is no necessity to determine the extent of passive movements. Only when limitation of active movement is present can an investigation of the range of passive movements be of any help.

If movements are restricted the diminution from the normal must be noted with the exact angle at which movement ceases. Again, the type of obstruction varies with the changes present in, or near the joint; thus, with a loss of movement due to a bony block the limitation is sudden and complete, and the surgeon feels that no further movement is possible, even with the use of great force, while in the limitation resulting from fibrous adhesions, or fibrous ankylosis, the block is not so sudden or so complete. If extra force is employed, pain and some slight increase of movement result, the preventive muscle spasm appearing at once if the limb is jerked.

Examination of the voluntary movements is also essential in infantile paralysis. The patient is asked to attempt the movements which are performed by each group of muscles, the loss of power in each movement being the indication of the presence of a complete or partial paralysis

Palpation. The examination of any suspected bone or joint lesion cannot be considered complete without careful palpation; by it an area of tenderness can be detected, and its exact extent defined, the consistency of growths can be appreciated, and in fractures the presence or absence of crepitus and abnormal bony prominences can be determined. Palpation is also of value in distinguishing the condition of the tissues in the neighbourhood of a suspected joint. Thus, the doughy sensation—which is characteristic of the periarticular infiltration in tuberculous arthritis—is of great value in the differential diagnosis, while osteoarthritis can usually be diagnosed on the rough creaking which accompanies movement.

Where possible the hands should be placed over the whole surface of the joint which is being examined If this routine is adopted in every case many diagnoses, which are otherwise extremely difficult, or even impossible, can be made with certainty. In no other way can the surgeon appreciate so well the slipping of a tendon over a bony prominence, or the noise which arises in a joint from some internal displacement, or roughening of the articular surfaces or of the synovial lining.

Inspection. The joint which is being examined should be completely uncovered while the movements are being performed. Examples of the advantages to be gained by inspection are numerous; thus, the recurrent displacement of the patella, the slipping of the peronei tendons, or the slipping of the gluteus maximus over the great trochanter can be

immediately recognized, whilst the diagnosis of such conditions by any other means is extremely difficult or impossible.

Radiographic Examination. The diagnosis of pathological conditions is often incomplete without radiographic examination, and in many instances of bone injury or disease a correct diagnosis can be reached on this evidence alone. It must always be remembered that this method of examination is only one of a series, and should never be used to supplant clinical observation and examination. Many orthopædic conditions can be diagnosed only by a careful clinical examination, the radiograph being used simply as a means of confirming, or disproving, a *diagnosis which has already been made on clinical investigation.*

CHAPTER II

SPLINTS AND APPARATUS

In the following chapters frequent references are made to the splints and apparatus which are in common use in the treatment of orthopædic conditions, and it is advisable that a short description of these should be given in order to avoid constant repetition. The description of many types of apparatus which are entirely satisfactory has been omitted, but those described are—in my opinion—the simplest in construction and the most effective in use.

Thomas Bed Knee Splint. Experience of war-time surgery has taught the medical profession some of the advantages of the "Thomas Splint" (Fig. 1). It was designed after much trial and many modifications to its present simple form It consists essentially of two round

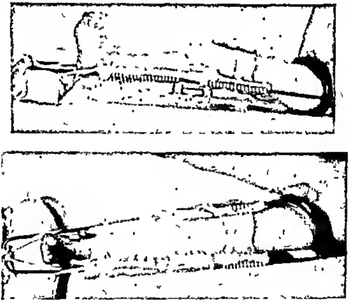


FIG. 1—Thomas Bed Knee Splint

iron rods, which are joined at the upper end by an oval ring of the same metal, and at the lower end by a transverse junction in which a depression—forming roughly the letter W—is placed for the fixation of extension.

There are certain fundamental points in the construction of the splint, of which one of the most important is that it is made of rigid unyielding iron and not of steel, which would alter in shape under pressure and could not give the immobility of the more rigid metal. The thickness of the metal bars depends naturally on the size of the splint, and varies between one-quarter and three-eighths of an inch, according to the pressure which is to be expected during its use. The ring joining the top of the lateral bars is formed of the same metal and is ovoid in shape, the two lateral bars being fused to it so that they exactly bisect its circumference. The angle made between the inner side of the ring and the inner lateral bar should be 120 degrees, whilst that between the outer bar and the outer portion of the ring naturally varies with the size of the splint. As the lateral bars descend from the ring to their lower attachment they tend to approximate, the distance between the bars at the lower extremities being roughly two-thirds of that between them at their attachment to the ring. The ring—which is designed to take the counter-pressure of the extension pull on the ischial tuberosity—is padded with felt and covered by smooth, firmly stretched leather. As all the pressure is applied on the inner and posterior margin of the ring, the felting is applied more thickly and firmly here than on the rest of the ring, where direct pressure is not borne.

In the treatment of fractures of the lower limb, and of inflammation, or disease of the knee-joint, the splint is of inestimable value. The basic principle underlying its use is the provision of complete immobilization of injured or inflamed tissues. Immobilization is effected by means of strapping extensions applied to the skin of the thigh and leg, or leg only. Through these, manual traction is applied to the limb. When no further yielding can be obtained, the extensions are tied round the W-shaped depression on the lower end of the splint, the object being the provision of complete immobilization. Following the immobilization there is an almost immediate disappearance of the reflex muscle spasm which invariably accompanies disease or injury of any of the tissues of the limb Gradually the skin extensions become loose and the tightening and fixation are repeated at intervals until the desired position of the limb is obtained, when further pulling of the extensions is only necessary if they have slipped on the skin. Although not part of the Thomas splint, yet essential for complete immobilization of a limb, is the straight metal back splint which extends from the upper part of the thigh to a point 3 inches above the malleoli. It is slung between the bars behind the limb, the slings being so arranged that at least two-thirds of the thigh and leg are placed in front of the lateral bars. A large pad of wool is placed between the back splint and the back of the knee-joint in order to retain the knee at a position of 5–10 degrees flexion, and to prevent subsequent deformity or troublesome rigidity.

In using the splint, extension and fixation are provided through the skin strapping, and the counter-pressure through the ring of the splint resting on the ischial tuberosity. If the splint is too large the ring may slip into the perineum, or even into the anal region when the desired immobilization cannot possibly be obtained. When the ring is of the correct size its postero-internal portion is held firmly in position against the ischial tuberosity. The skin of this area is accustomed to pressure, and irritation between the ring and the tuberosity need not be feared if simple hygienic measures are employed. At first, every few hours, and later at longer intervals, the skin of the area is gently rubebd with methylated spirit, the excess being rubbed off and replaced by dusting powder.

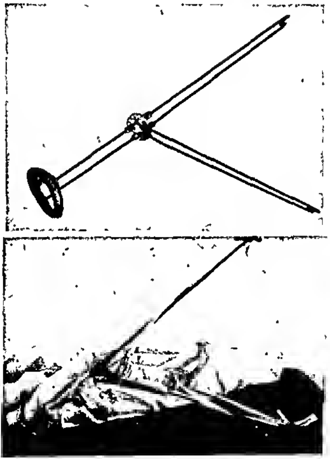


Fig. 2.—Thomas Two-way Bed Knee Splint

Two-ended Bed Knee Splint. A modification of the Thomas bed knee splint which has proved of value is the two-ended Thomas splint (Fig. 2), the construction of the upper portion of the splint being identical with the original. Two adjustable extension ends are fixed to a double flat ratchet at the level where the knee will be placed when the splint is applied. The angle of fixation of these ends can be altered to any position and stabilized there by tightening the ratchet.

The splint is used for the correction of the subluxation, which is so often present, in old-standing fibrous ankylosis of the knee-joint. If an attempt is made to straighten this deformity without attention to the displacement of the tibia the subluxation will be increased. By use of the splint the head of the tibia can be pulled forward into line with the femur while the angle of flexion is being altered. This method of application and use is illustrated in Fig. 2. Through one pair of extensions the limb is gradually straightened, while by a pull at right angles to the head of the tibia this bone is gradually pulled forward into line with the femur.

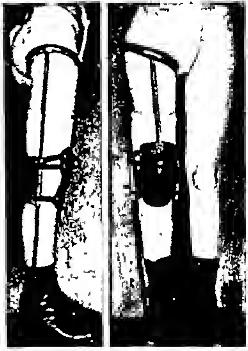


Fig. 3.—Walking Caliper.

Caliper Splint. This splint, which is of almost universal use in the ambulatory treatment of injuries and disease of the thigh, knee, and leg, was developed from the bed knee splint and resembles it in structure with certain modifications, which are designed to promote more efficient and comfortable use in walking (Fig. 3). The lateral bars and ring of the splint are made of the same metal as the bed knee splint, the chief modification being the structure of the upper ring. In contrast with the bed knee splint this is not ovoid in shape, the back of the ring is flattened, and the two lateral bars are attached behind the middle point of its circumference. In addition, the back of the ring on the inner side, behind the attachment of the inner bar, dips downwards to an angle of 5 degrees. These modifications are so designed that the splint fits snugly and takes its pressure solely on the ischial tuberosity. The lateral bars are not joined at their lower

end but are bent in at right angles at a point one inch below the level of the heel, the cut ends of the splint, 1½–2 inches in length, being placed when in use in a metal tube extending obliquely through the heel of the boot.

By the application of extension ends to the caliper the splint may be retained for 2 or 3 years if necessary in a growing child, being lengthened at intervals to suit the growth of the patient. The metal tube through the boot heel is preferably made of brass and is inserted at an angle in the line of the boot, its inner opening being usually placed ½ to ¾ of an inch behind the outer opening, the angle of obliquity being altered according to the amount of external rotation of the limb desired for each patient.

A strap of leather, 4 inches wide, extends between the bars behind the knee joint, maintaining the knee in a slightly flexed position, whilst a narrow leather binding strap is placed between the bars 4 inches above the lower extremity. An anterior knee pad may also be added, or its place may be taken by a bandage which controls movement and prevents flexion of the joint.

A cloth boot with a leather sole is usually advisable for the patient when walking is resumed after prolonged recumbency. With the soft cloth upper, and with the complete fixation provided by the firm leather sole, the patient can wear the boot continuously To prevent the development of a pressure point on the back of the heel the boot should be removed once each day whilst the foot is washed, rubbed with methylated spirit, dried and dusted with powder, the limb being held immobile whilst this is being done

Various slight modifications may be made in the caliper to suit particular conditions; thus, with a very thickened and swollen knee-joint it may be advisable to bow out the inner or outer bar, allowing room for the distended joint.

If it is necessary for a patient to wear a caliper for years, the continued pressure of the ring may cause inconvenience and irritation, especially in the adult. This may be avoided by replacing the caliper ring by a laced top, similar to that used in an artificial leg; this modification allows the pressure to be borne over a wide area of the upper thigh and ischial region, and is usually much appreciated.

The provision of a hinge in a caliper splint at the level of the knee joint is also a great comfort, especially in the case of a flail limb of an adult. The ability to bend the knee in sitting is appreciated by the patient when travelling, but the use of the hinged caliper is only permitted in those cases where all hope of recovery from paralysis is abandoned

Thomas Heel. One of the simplest and most useful methods of altering the line of weight bearing in a weak, abducted or flat foot is

provided by the shoe alteration described by Thomas. To be effective the alteration can only be made to a firm walking shoe with a wide, low heel. The shoe must closely fit the foot, especially round the heel, in order that the alteration in the tilt of the heel may be transmitted to the foot and ankle and not cause a simple sliding of the whole foot towards the outer side.

In the alteration the heel is first removed from the shoe and is then built anew, the leather of each section being cut so that the height of the heel is greater on its inner than on its outer margin (Fig. 4). The difference of the two sides should vary between one-eighth and one-quarter

FIG. 4.—Thomas Crooked and Elongated Heel.

FIG. 5.—Thomas Crooked and Elongated Heel with Sole Piece.

of an inch, according to the age of the patient and amount of correction desired. In addition to the difference in its height, the inner margin of the heel is elongated towards the sole of the shoe for half an inch, in order that a better control can be given to the tarsal region of the foot

In the treatment of a mobile flat foot no further alteration to the shoe is required, but when, in addition to the correction of an eversion of the foot, it is desirable that the foot should be rotated inwards while walking a pad of leather (Fig. 5), one layer in thickness, should be added to the inner margin of the sole in the region of the head of the first metatarsal.

Double Frame. In the treatment of injury or disease of the spine correction of the deformity, or immobilization, can be obtained by the

use of a plaster bed or of a Thomas double frame (Fig. 6). When the frame is used the patient is more easily nursed, the back can be cleansed without movement of the affected area of the spine, wider exposure of the body to wind and sunlight can be obtained, whilst at the same time a certain amount of correction of deformity is occurring. The frame con-

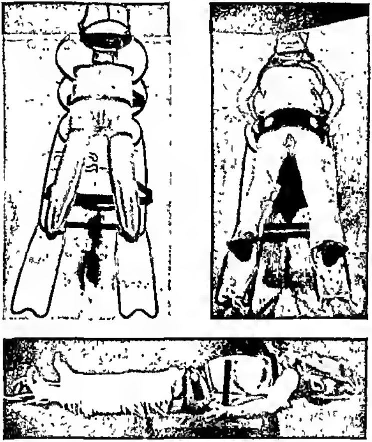


FIG 6 —Thomas Straight Frame with Headpiece and Gallows

sists of two straight, flat. iron bars, which vary in thickness and strength according to the length of the frame In its construction these two bars, which form its basic support, lie 2–4 inches apart at their upper ends, the lower extremities diverging another 2–4 inches These two main bars are joined by transverse bands at three points, the lowest being just above the lower ends, where a short iron grip is placed for the fixation of the ankle on each side. The upper two connecting bars are designed so that

they may meet in front over the patient on the splint, and are constructed of mouldable iron which can be bent.

The back of the frame is covered by a firmly packed leather-covered pad of lambswool, which extends unbroken from above the upper border of the frame to a point below the second transverse bar, and just above the position in which the patient's buttocks will lie when the frame is in use. From this point downward the pad is continued on each posterior bar, leaving a wide gap in the middle, through which the necessary nursing attention may be given without movement of the patient from his fixed position.

An adjustable headpiece, which extends from the upper ends of the two back bars, adds considerably to the immobilization and may be arranged at any position which is found to be suitable. As an additional security, thin metal bars may be added to the outer side of the lower portions of the splint so that the legs and knees may be steadied and deformity prevented.

After placing the patient on the frame, attention to the skin is quite simple; any spot, such as the buttock, on which extra pressure is borne, should be rubbed frequently with a fine cloth soaked in methylated spirit, and the area subsequently dusted with powder, the cloth being slid between the patient and the pad without altering the patient's position in any way. In this way the patient may be retained on the splint without removal, and without the development of abrasions or pressure sores, for months or years if necessary.

Abduction Frame. This splint, which is commonly used in the treatment of disease of the hip-joint, is a simple modification of the double frame (Fig. 7). The construction is almost identical, except that one of the posterior bars is bent outwards to a varying angle, usually 10–20 degrees, at the point where the patient's buttock on that side will be placed. The headpiece is unnecessary on this frame, but extension irons are added on each side, and on the second circular lateral bar provision is made on the straight side for the application of a groin strap by which counter-extension may be employed. The pull on the affected side is taken by skin traction, the groin strap on the sound side retaining the pelvis in its normal position, thus permitting the angle of the affected hip-joint to be altered by stages.

Posterior Spinal Support. The Thomas posterior support is simple in its construction, effective in action and easily applied (Fig. 8). It is made on the principle that, when the patient is erect, effective protection can be given to a diseased or injured spinal column only against antero-posterior strains. No form of support can prevent pressure passing vertically through the diseased or injured area, and all efforts to support the spine by means of axillary crutches are entirely futile.

The support is constructed of an irregular framework of flat bar

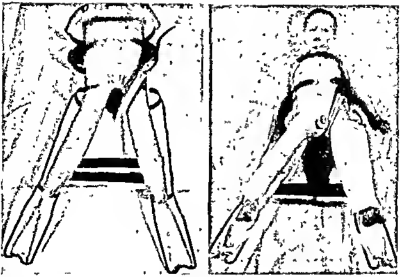


Fig 7.—Jones Abduction Frame.

Fig. 8.—Thomas Posterior Spinal Support.

iron, moulded into the suitable shape. This framework is covered with a thin layer of fine felting, which is first firmly stitched in position, and the whole then covered by a coating of thin, uncreased leather. To the lower portion of the splint is attached a stout canvas and leather belt which, on application of the splint, is buckled firmly round the patient's pelvis between the great trochanter and the cresta of the ilia. Padded arm straps are attached on either side on the upper portion of the splint, and after encircling the shoulders these are tied to a buckle above the middle of the support. The frame is so designed that, when the pelvic strap has been firmly tightened and the body of the splint lies in contact with the lumbar spine, the upper part of the support sits out from the back, thus allowing for a corrective pull on the shoulders towards the splint, the tendency to flexion deformity being thereby relieved.

The support is more comfortably worn over a thin singlet and should only be removed once a week for change and washing of the back. The removal is carried out as follows: the patient lies flat on the face, the straps of the support are untied from the back, the frame is removed and the singlet gently pulled over the head. The back is now washed and rubbed with methylated spirit and dusted with powder before the clean singlet is applied. The splint is now reapplied, the straps are tightened and, with care, the whole operation of removal, washing and reapplication can be performed without movement of the affected spine.

Thomas Collar. The Thomas collar (Fig. 9) is made in two

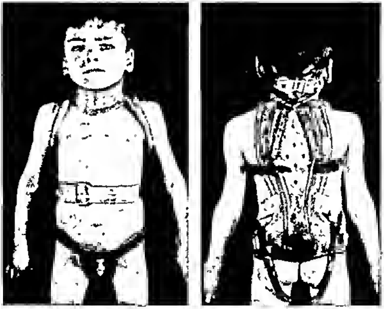


FIG. 9.—Thomas Posterior Spinal Support with Thomas Collar.

distinct types, the simple semi-rigid type, made of a frame of stiff leather or felt, covered by washleather, and fixing at the back of the neck, by means of a buckle, the whole being held in position by a thin canvas strap extending round the chest.

The more rigid Thomas collar is composed of a rigid leather basis, moulded to the shape of the neck, lower jaw and occiput, inferiorly being moulded closely over the upper part of the chest and shoulders. By the use of this latter type an efficient immobilization of the cervical spine can be obtained, an essential factor in the treatment of Pott's disease when the ambulatory stage has been reached.

Shoulder Abduction Splint. When prolonged immobilization of the shoulder is being used in the treatment of disease of the shoulder-joint it is sometimes advisable that, during the period of fixation, the joint should be retained at the optimum functional position This position must be maintained during the whole period of immobilization, because cure of the active disease is so frequently followed by ankylosis

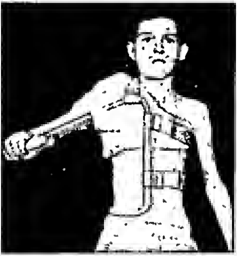


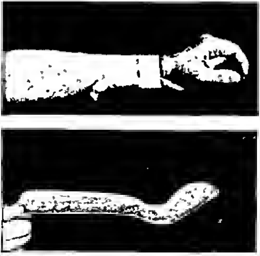
Fig. 10—Abduction Arm Splint

of the joint. This optimum position varies with the age of the patient being, in the adult, 50–70 degrees abduction from the chest-wall, and 20–25 degrees in front of the plane of the body. The fixation is often obtained by the use of a plaster of Paris case which includes the chest and upper part of the abdomen, extending to the hand on the affected side. The great weight of such a mass of plaster is the chief drawback to this method; equally good immobilization can be obtained by one of the comparatively light abduction frames (Fig. 10).

The simplest and most comfortable type of shoulder abduction splint is that made from a single continuous strip of round iron wire, extending down both sides of the arm and forearm, across the palm of the hand and across the front and back of the chest, slightly beyond the middle line. From this spot it continues downward in front and behind to the level of a point between the great trochanter and the iliac crest, where the band passes transversely from the front to meet the posterior vertical portion.

The whole frame is padded with felt, which is especially thick over the posterior portions where extra pressure is applied during recumbency. The weight of the splint is borne on the lower transverse bar, which should take its pressure on the strong fascia between the great trochanter and the iliac crest. The arm portion of the frame is moulded into the desired position, which varies to some extent according to the age of the patient and to the mobility of the scapula on the chest-wall.

Straight Metal Splints. Straight malleable metal splints of sheet iron or duralium are useful in the treatment of many orthopædic conditions. The latter type have the advantage that radiographic examinations are possible after their application, but have also the disadvantage that they are not so firm and do not retain the position of moulding as well as the sheet-iron splint. The gauge of metal of which the splints are constructed varies according to their length, being of such thickness that manual moulding is possible.



FIGS. 11.—Short Cock-up Hand Splint.

Hand Splints. These sheet-metal splints are of two types, the long, by which the wrist, hand and fingers can be maintained in any position of choice, and the short, which is designed to control the movements and position of the wrist-joint, the fingers being left free (Fig. 11).

The long hand splint has a shallow concave forearm piece, which joins the hand-piece at an angle, the hand-piece extending to the tips

FIG. 12.—Long Cock-up Hand Splint

of the fingers, being convex on its upper surface from before backwards and from side to side, thus preventing hyperextension and rigidity at any of the joints of the hand or fingers (Fig. 12).

Plaster of Paris.

The use of plaster of Paris is so widespread in orthopædic practice that it is necessary for the surgeon to know its composition, and the technique of its application. The plaster, or calcium sulphate, may be used as a thick paste in which bandages, or layers of gauze or lint, are soaked before they are transferred to the area which is to be immobilized. The more usual method is to use loose-meshed crinoline bandages, into which the dried plaster is rubbed. These are placed end upward in a bucket of tepid water, and after all air bubbles have ceased the bandage is removed and gently squeezed at both ends to remove the excess of water. It is then ready to apply, the whole operation of putting on a sufficiently thick and firm plaster requiring about 5 to 10 minutes. As the separate layers are added each should be rubbed in to that already in position; by this means the plaster forms one strong, adherent unit and does not show any tendency towards flaking in the different layers.

Methods of Application. The plaster may be applied directly to the skin, without any protective covering, the fixation by this means being extremely effective, the chief danger being the risk of pressure sores over bony points. If these sores can be prevented by careful moulding of the case over the danger area, complete immobilization is obtained. The more usual and safer method of application is by the use of a closely fitting stockinet covering, completely enclosing the area to be immobilized, and reinforced by felt padding at the points where excessive pressure is to be expected. A thin layer of wool may be used in place of the stockinet; the wool should be of the type used by tailors with a semi-solid backing, which prevents sliding and rucking.

When the area has thus been prepared, the plaster bandages are applied; if stockinet is not employed, the first and all subsequent layers must be applied lightly and without tension. If stockinet is used, the

first layers of plaster are applied with moderate and equal tension, and all subsequent layers are added loosely to prevent the formation of creases on the inner side of the cast.

The ideal plaster splint is one which is of equal thickness over its whole extent, but in certain areas—such as the hip or knee-joint—where the cast will be subjected to excessive strain, a reinforcement should be added. This additional strength is provided by a plaster slab placed across the suspected area, and held in place by further turns of the plaster bandage.

The edges of the cast should he cut and turned to prevent irritation of the skin, and when including the foot or hand the cast should always be open at the end to allow inspection of the toes and fingers. Setting of the case usually takes 8–10 minutes, but if subjected to continued local pressure during the following hours, dents may be made in the cast, causing pain and possibly interference with the circulation. To prevent this complication the cast should be supported on a flat, smooth surface until it is quite dry, thus maintaining the desired position.

In removing plaster casts, various forms of cutters and shears are available; of these the most satisfactory is the Stille pattern plaster cutters, by which even closely fitting casts may be removed with little discomfort.

Although these rules will help the surgeon in the use of plaster-of-Paris splints; skill can only he obtained by practice and by experiencing complications which have just been mentiooed. A survey of the advantages and disadvantages of plaster fixation helps the surgeoo in deciding when he should use this method, and when he should rely on splintage.

The advantages of its use are obvious:

1. A plaster splint or case may be applied to fit any deformity.
2. There is no necessity for the adjustment of the apparatus.
3. The fixation produced in plaster of Paris is hetter than that obtained in aoy form of splint.
4. The patient cannot remove the splint.
5. The case may be retained for long periods without alteration.
6. The plaster case does not tend to shrink after application.

There are, however, several disadvantages to the use of plaster:

1. Sores may develop under the plaster without giving any definite clinical signs.
2. The use of plaster of Paris is difficult or impossible in the presence of discharging sinuses.
3. Abscesses may form in a diseased joint which has to be fixed in plaster without the possibility of their early recognition by the surgeon.
4. Open air and sunlight are entirely precluded from the area of disease or injury.
5. The weight of the plaster case is often objected to hy the patient.

CHAPTER III

RIGIDITY OF JOINTS

The normal range of movement in a joint may be diminished or lost through changes in the joint itself, in its capsule, or in the tissues external to, and not in close relationship to, the joint structures. The problem of rigidity, and of the pain which so often accompanies the limited range of motion, is one which has not received the attention it deserves from the medical profession. This has been recognized by the lay public, who have in the past relied on the advice of unqualified practitioners, most of whom have no knowledge of the pathological changes causing the rigidity. The art of manipulative surgery has been practised from time immemorial, and the practitioners of the art have received from the lay public an amount of respect which is often unjustified by the results obtained.

The principles underlying successful manipulative surgery do not differ in any way from those which apply in any other branch of medicine or surgery, and whilst a certain amount of credit may be obtained by the ignorant manipulator, continued success in the practice of this form of surgery must depend on a knowledge of the pathological processes underlying the disability.

The causes of diminished movement in a joint may be classified under the following headings.

1. Functional Rigidity
2. Muscular Spasm
3. Adhesions
4. Bony Blocks
5. Ankylosis

Each one of these conditions can be recognized by a series of signs and symptoms which are characteristic, and success in the treatment of the rigidity depends solely on the success or failure in arriving at the correct diagnosis

FUNCTIONAL RIGIDITY

Partial or complete limitation of movement of a joint in which no pathological changes can be demonstrated is found most commonly in young, nervous female patients. It may, however, be seen in strong, healthy men, particularly after some severe shock by which the general equilibrium is upset.

The condition is usually easy to recognize, but on occasion there may be considerable difficulty before the correct diagnosis is reached The

affected joint is normal in contour, there is no swelling unless the patient has deliberately caused this by circular compression of the affected limb. The joint is generally held in a position of extreme deformity; thus, in the foot the typical functional deformity is an extreme equino varus with apparent shortening of the invertor muscles.

Diagnosis. The correct diagnosis can only be reached by a process of elimination, and no diagnosis of functional disorder should ever be made without the most complete examination.

MUSCULAR SPASM

When the structures of a joint, or of its periarticular tissues are inflamed from any cause, movements are restricted or lost by an involuntary protective spasm of the muscles which control its function. This spasm becomes apparent on any attempt at movement in the inflamed tissues, and this reaction of protection remains until all signs of the causative inflammation have disappeared.

Following the cessation of spasm, movement in the joint is gradually restored, and the degree of restoration depends on the completeness of the removal of the inflammatory process. The muscle spasm is simply an effort on the part of Nature to restrict movements and to protect the affected area from trauma, the necessity for this protection disappearing when the inflammatory changes have subsided. If, however, the inflammation in or round the joint has caused thickening, shortening or the formation of adhesions between any of these normally pliable tissues, then movements which stretch these tissues produce pain, and a protective spasm immediately appears. The treatment of the muscular spasm is, therefore, bound up in the treatment of the changes from which it originates.

ADHESIONS

The most frequent cause of the lesser degrees of limitation of movements in a joint is the presence of adhesions in the neighbourhood. For descriptive purposes these adhesions may be divided into two classes:

1. Intra-articular Adhesions.
2. Peri-articular Adhesions.

Intra-articular Adhesions. When a joint is inflamed or injured its usual reaction consists in the outpouring of an abnormally large amount of serous or hæmorrhagic fluid which is, as a rule, absorbed after a varying interval, leaving the joint structures unaffected. Following such a sequel of events the movements of the joint are restored to their pre-inflammatory range, but if the lining—either the synovial membrane or the articular cartilage—has been injured, limitation of

movements to a greater or lesser degree is the invariable result. With the disappearance of the excess of fluid which has kept them apart, the inflamed tissues become approximated, fibrous bands form between the injured surfaces with a consequent restriction of movements. When the inflammation has been confined to the synovia, as may occur in any of the several types of synovitis, the adhesions are formed solely between neighbouring injured portions of the synovial membrane. If, however, the articular surfaces have also been involved in the process, as with destructive arthritis, these bands stretch between neighbouring articular surfaces, or between them and the synovial membrane. Such intra-articular changes most commonly follow on inflammatory or septic infection of the joint, but fibrous restricting bands may also be formed as a result of a fracture into the joint, by which the continuity of the articular surfaces has been interrupted. At first the newly formed fibrous tissue is vascular and easily stretched, but gradually it becomes avascular and rigid so that the restriction to movement is more complete.

Peri-articular Adhesions. The normal movements, even of a healthy joint, are only possible when the muscular and ligamentous tissues surrounding the joint retain their normal range of movements and elasticity. Adhesions may form round a joint from many causes; thus, as a result of a blow or twist hæmorrhage may occur into the peri-articular, muscular or ligamentous tissues. This hæmorrhage organizes and forms fibrous tissue, with the result that the normal elasticity is lost and the range of movement in the joint is diminished because of this rigidity, and also because stretching of these rigid tissues causes pain and is, therefore, avoided. Adhesions in the tissues round a joint may also form as a result of inflammatory processes Such inflammation may arise from many causes, thus, mild septic infections, exposure of the part to cold or draught may each result in the formation of adhesions with limitation of movements. Similarly, when a ligament is stretched beyond its natural elasticity its fibres are injured at their attachment to bone. At this spot the same sequel of events takes place, hæmorrhage, fibrous tissue formation, limitation of movements, and pain on attempted active or passive movements.

This organization of hæmorrhage into fibrous tissue usually takes place in 3–6 weeks, during which period the movements of the joints gradually become less painful, while the resistance to any movement which stretches this fibrous tissue is becoming more definite. According to the extent of the injury, hæmorrhage and subsequent adhesions may be present all round the joint, but more commonly they are limited to one aspect, and their presence may only be suspected when the affected tissue is put under strain by some particular movement

Diagnosis of Adhesions

The presence of adhesions in the neighbourhood of a joint, which is radiographically normal, may be suspected if movements are restricted in one or two directions, whilst the other movements are free when compared with the normal joint. If all movements of a joint are lost the cause can be found in true intra-articular changes, but if voluntary movement in any direction is free, full and painless, arthritis cannot be present.

When the adhesions are extra-articular their exact site can usually be defined by the discovery of tenderness on digital pressure. This sign is also of value in distinguishing between recently formed vascular adhesions, which are often acutely tender, and the rigid avascular fibrous bands which are usually entirely insensitive. The reaction of a suspected joint to exercise also gives valuable evidence in regard to the cause of the rigidity. Thus, swelling and further restriction follow on the activity of an inflamed joint, while free use of a joint, whose movements are restricted by adhesions, produce a steadily increasing range.

Intra-articular adhesions are produced by infections and hæmorrhage into the joint cavity, whilst peri-articular adhesions usually follow on direct injuries in the neighbourhood of the joint, or strains of the ligaments attached to the joint capsule, or are a sequelæ of infections or inflammations in the tissues round the joint. The term "intra-articular adhesions" should be confined to those fibrous bands which extend from neighbouring portions of the synovial membrane, binding them together and restricting the range of active motion of the joint. The fibrous bands, which form between injured articular surfaces as a result of their partial or complete destruction of the articular cartilage covering the bone ends, should be defined as inter-articular adhesions, as indicating their position between the articular surfaces.

It is often difficult to differentiate clinically between intra and extra-articular adhesions. The two conditions have many features in common; thus, in each there is, as a rule, some range of clear, painless movement. In neither condition are the changes accompanied by a rise of temperature, either general or local, and, as a rule, appreciable swelling is not present, either in the joint or in the peri-articular tissues.

There are, however, certain features which help in the differential diagnosis; thus, intra-articular adhesions always follow on inflammations and excessive swelling of the joint itself, while peri-articular adhesions are usually caused by an injury or strain which is not accompanied by synovial effusion. Again, in the presence of intra-articular adhesions, the full range of free movement in any direction is usually restricted, while one of the outstanding features of peri-articular adhesions is the free, unrestricted, painless range of movement in at least one direction.

Treatment of Adhesions in the Neighbourhood of Joints

The treatment of adhesions in the neighbourhood of joints may be divided into two stages:

1. Preventive.
2. Active.

Preventive Treatment. The so-called "adhesions of disuse" are usually the result of prolonged immobilization of a joint, in which the lining membrane or the peri-articular tissues are the seat of inflammatory changes They may also be the result of the prolonged fixation of a joint in an abnormal position, a "normal" position of a joint being taken as an angle between the extremes of flexion and extension. This question of the correct position of immobilization is of the very greatest importance; if a normal joint is immobilized in a "normal" position no rigidity results, but if the joint has been maintained in a position in which any of the ligaments have been subjected to continuous strain, adhesions are formed at the point of strain

Again, after injury to a joint or to its surrounding tissues, the whole area becomes swollen, infiltrated and thickened. This inflammatory swelling, if left untreated, will probably lead to a limitation of movements through the formation of adhesions between the inflamed tissues. Dispersal of these inflammatory products depends largely on improvement in the local circulation. Protection of the injured tissues from further trauma, massage of the area, radiant heat and encouraged active movements all lead to a localized vaso dilatation and to the dispersal of the inflammatory mass. If, in spite of this form of preventive treatment, there is no improvement, or where adhesions have already formed, the second line of treatment must be adopted.

Active Treatment. *Two conditions are essential for success in* the treatment of adhesions by manipulation, whether intra- or peri-articular. The first of these is the absence of destructive changes in the articular surfaces of the affected joint These, if present, would not prevent movement of the joint under anæsthesia, but the manipulation would be followed by such pain and swelling that subsequent active movements would be impossible The second condition is the age of the adhesions; when first formed adhesions are loose, elastic, highly vascular bands which would tear easily when subjected to tension, but would *re-form rapidly* because of their high vascularity. Adhesions which have been present for a considerable period gradually become avascular, being converted into dense fibrous tissue, the blood vessels disappear, and after rupture there is little tendency towards re-attachment

It may, therefore, be stated that, during the early stages when adhesions are forming in or around the joint, they may be, to a large

extent, prevented by massage, radiant heat and active movements. After their formation such treatment will improve the tone of the muscles, but cannot disperse firm adhesions without their preliminary rupture by the use of forced passive movements, either with or without anæsthesia. One other factor may lead to failure following manipulation performed with the object of breaking down adhesions. Such an operation is frequently followed by considerable pain, and if the patient is not encouraged and helped to use the joint freely, and is allowed to hold the limb in the position in which it is comfortable, no improvement can follow even a correctly conducted operation. The operation of manipulation must, therefore, always be followed by a course of assisted voluntary movements, combined with massage, which act together in restoring movement.

Although there are many special points to be remembered in the technique of manipulation of particular joints, certain principles are applicable to all manipulations. The first and most important of these concerns the necessity for gentleness in the performance of any passive movement, with or without the help of anæsthesia. The affected joint should, if possible, be put through its full range, one complete movement being performed in each direction. Repeated movements are of no advantage; they only cause irritation, and may be followed by traumatic synovitis, or even arthritis.

The second essential for success in manipulation is the use of gentle, steady pressure during the whole procedure. If sudden, uncontrolled force is used, soft tissues may be torn, or a fracture may occur in a bone whose strength has been diminished by prolonged immobilization. The prospects of success following a manipulation can be judged by the sensation given when the adhesions are torn. If a sudden, sharp snap is felt the result will be satisfactory, as the adhesions are probably avascular and fibrotic, while an indefinite feeling of tearing round the joint indicates usually the presence of more vascular adhesions, with the probability of re-formation. Although these rules are applicable to most joints there are certain exceptions in which the reaction to manipulation is definitely unfavourable. The two outstanding exceptions to the general rule are the elbow and the metacarpophalangeal and interphalangeal joints, where manipulation is often followed by a diminution rather than an increase in the range of movement.

The reaction of these joints is so unsatisfactory to the ordinary type of manipulation that a specially modified technique should be employed. The affected joint should be moved through a few degrees and fixed in the new position for 24 hours, active movements should then be encouraged, and if the increased range has been maintained a further stage may then be attempted. In the finger-joints, stiffness is often caused by a combination of adhesions and traumatic arthritis,

and any attempt at forced movement during the active stage of the arthritis is doomed to failure. Considerable improvement in both the arthritis and the adhesions follows on physiotherapy, consisting of radiant heat, hot bathing, massage and gentle passive movements. In fact, more benefit in the treatment of finger rigidity is obtained by physiotherapy than by the most carefully executed manipulation.

If the attempt to gain further movement in the elbow-joint has been unsuccessful, there is, as a rule, no advantage to be gained from physiotherapy. Active use of the joint up to the point at which pain is developed should be encouraged, and this routine usually improves function and the scope of movement.

Treatment of Inter-Articular Adhesions

When fibrous bands have formed between the adjacent articular surfaces and between these and the capsule of the joint, a decision as to the possibility of obtaining a useful range of painless movement in the joint is usually a matter of extreme difficulty. Help in making the decision is given by the radiograph, where gross irregularity of the joint surface may be taken as a definite contra-indication to manipulation. As a rule the fibrous tissue extends not only between the articular surfaces but also between neighbouring portions of the synovial lining, and between this membrane and the bone ends The possibility of improvement under these conditions depends not only on the extent of the destructive process but on the nature of the causative arthritis. If resulting from tuberculous infection any attempt at passive movement must be avoided, because of the fear of lighting up the quiescent disease If, however, the articular changes have resulted from a pyogenic infection of the joint, the possibility of restoring a useful range of movement depends largely on the severity of destruction present in the articular surfaces. If the destruction is extensive, with a diminished joint space, manipulation is likely to be followed by great inflammatory reaction in the joint, by great pain and swelling and no increase of function. If, however, the joint space is little affected; with only slight destruction of the *articular surfaces, it is probable that a gentle manipulation under* anæsthesia will be followed by a negligible reaction, and by an increased range of active movement. If it is considered advisable to attempt the manipulation certain important precautions must be adopted Any attempt at putting the joint through its full range of movements, as in the case of peri-articular adhesions, is certain to fail in its object.

To understand the routine which should be followed in this procedure, a knee-joint—with inter-articular adhesions, without much change in the joint space, and with very slight alterations in the articular surface—may be taken as an example (Fig. 13).

Under full anæsthesia the joint is bent through an angle of 30–45 degrees, the range depending on the amount of resistance encountered. The joint is now placed on an inclined plane at the maximum angle

FIG. 13.—Manipulation of Knee, shaft of femur protected by assistant.

obtained under anæsthesia (Fig. 14). The following day, when the pain is less, the patient is encouraged to extend the joint, gentle massage being given to the thigh and knee to improve the circulation and diminish any

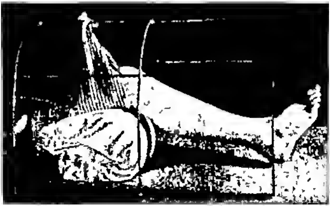


FIG. 14.—Knee suspended after Manipulation.

swelling which has followed the manipulation. No further flexion is attempted until the full power of extension has been restored. If the joint remains in the flexed position, after a fortnight's encouragement and massage, it is evident that active movements are not possible, and the

joint should be allowed to return to the position of full extension where it may be more easily protected from strain, and will be of the greatest functional use. Even though the attempt has failed, rest of the joint for 3–6 months may result in an improvement, and another attempt at increasing the range of movements may then be successful. If, however, the power of extension of the joint is restored, further flexion may be undertaken on several occasions, until the range of voluntary movement is in the region of 90 degrees, further movement usually resulting from normal use of the joint.

RIGIDITY DUE TO BONY BLOCKS

Limitation of movement in a joint may be caused by the presence of abnormal bony formations in its neighbourhood. These prominences may be the result of mal-union or excessive formation of callus round a fracture in the neighbourhood, or may be of new formation, as in myositis ossificans traumatica.

Treatment

The treatment of the rigidity depends entirely on the cause of the bony tumour. When resulting from mal-union of a fracture the limitation of movement is always caused by a combination of two elements, the mechanical block and widespread adhesions The greater the mal-union the more extensive the adhesions, and although it may appear from a radiographic examination that the limitation is entirely due to the bony abnormality, manipulation of such a joint usually results in rupturing the adhesions, and an increased range of movement in the joint can be obtained

In deciding on the course of treatment which should be adopted in any particular instance, the adhesions should be dealt with first by manipulation, after which it may be considered inadvisable to interfere with the bony mass. If further movement is desired it is usually advisable to remove the excess of callus, or to chisel off any projecting spike of bone which limits movement, rather than attempt to reconstruct the fracture with the inevitable risk of the re-formation of the obstructive mass. The treatment of myositis ossificans traumatica is dealt with in Chapter XV.

ANKYLOSIS

The term ankylosis, or absence of movement in a joint, is usually applied to the condition of rigidity which is caused by the presence of a band of union between adjacent articular surfaces. When a joint is surrounded by a mass of strong peri-articular adhesions, movements

may be impossible, even though the articular surfaces are normal. Such a condition is correctly described as complete rigidity, whilst a similar loss of movement, caused by the effects of erosion or disintegration of the articular surfaces, is an ankylosis.

Ankylosis can be divided into two classes according to the nature of the material joining the articular surfaces:

1. Bony ankylosis.
2. Fibrous ankylosis.

Another and more useful clinical classification of ankylosis is that given by H. O. Thomas:

1. *Sound ankylosis*, which may be either bony or fibrous in nature, but is of such strength that no alteration in the position of the ankylosed joint results from functional activity.
2. *Unsound ankylosis*, which is always fibrous in character and in which use of the joint is followed by an alteration in the angle of fixation.

The two clinical types of sound and unsound ankylosis are not entirely distinct; an unsound ankylosis may, by suitable treatment, be converted into a sound ankylosis. The stability of the fibrous tissue, which joins the two roughened articular surfaces, determines the character of the ankylosis. When long and weak it allows alteration of the angle of fixation, when short and strong the position is maintained in spite of strain. If the long, weak, fibrous mass can be protected for a sufficiently long period it becomes firm and more resistant, thus altering the condition of the joint from an unsound to a sound ankylosis.

Prevention of Ankylosis

The preventive treatment of ankylosis is in reality the early treatment of infective arthritis, as described in Chapter XXIV, or the treatment of chronic arthritis, as described in Chapter XI.

Treatment of Ankylosis

Many problems are encountered in the treatment of fully developed ankylosis, the first and most important being the advisability of altering the position, or the type of ankylosis, or the conversion of the ankylosed into a mobile joint. When the ankylosis is sound, painless, and the affected joint is in good position and does not interfere with the patient's work or pleasure, no treatment is usually advisable or necessary. If, however, the patient insists on having a movable instead of an ankylosed joint, the various advantages and disadvantages of such a procedure should be enumerated. Thus, with most joints, although it may be possible to obtain movement, such improvement in function is usually

accompanied by a varying degree of instability. If the ankylosis is painless, it is impossible for the surgeon to guarantee that the increased movements resulting from the operation will be equally painless.

There are, however, certain considerations in regard to work or play which persuade the patient, or the surgeon, of the advisability of performing some type of mobilizing operation on an ankylosed joint. In some instances, movement at the elbow is necessary in the patient's business. In others, the presence of two ankylosed hip-joints may make the patient's life extremely uncomfortable, and movement—even though accompanied by some loss of stability—is often of the very greatest service.

It may be laid down as a rule that operations on ankylosed joints may be advisable with the following objects in view:

1. To correct deformity.
2. To convert a painful into a painless ankylosis.
3. *To give movement where this is essential.*

To obtain these results five principal operative measures are employed, and any of these methods may be advisable under certain circumstances in a particular type of ankylosis. These operations are·

1. Osteotomy.
2. Arthrodesis.
3. Arthroplasty.
4. Pseudarthrosis
5. Excision.

The advantages of any one method can best be appreciated by the consideration of ankylosis occurring in each joint separately

Ankylosis of the Elbow-joint

Sound ankylosis of the elbow joint causes the minimum of disability when the joint is fixed about 10 degrees below a right angle If the *rotation at the superior radio-ulnar joint is also likely to be lost the* forearm should be placed midway between pronation and supination. Ankylosed in this position, the elbow-joint usually gives little inconvenience to the patient and the functional activity is little less than normal. If, however, the ankylosis is painful, or if movement at the joint is essential for the patient's work, the choice of treatment lies between arthrodesis, arthroplasty or excision of the joint.

Arthrodesis of the Elbow. The operative fusion of an unsound, painful elbow, and its conversion into a painless, rigid joint is very rarely necessary. As a rule, fixation of such a painful elbow in a plaster or leather case for 6–12 months results in the disappearance of pain, and the development of a sound ankylosis, which does not alter its position, even with prolonged functional activity. Very occasionally it may be

necessary to perform a combined intra- and extra-articular arthrodesis, the technique of which is very similar to that described for arthrodesis of the hip-joint.

Arthroplasty of the Elbow. Movements in an ankylosed elbow-joint may be obtained by the operation of arthroplasty, in which a thin layer of bone is removed from the lower end of the humerus and the upper end of the radius and ulna, the normal contour of the bony structures being more or less retained, while the soft tissue lining of the joint is replaced by an interposed layer of transplanted fascia lata. Through a long posterior incision, extending for 6 inches above and 4 inches below the tip of the olecranon, the triceps muscle, its tendon of insertion and its expansion into the subcutaneous border of the shaft of the ulna are split in the middle line. The posterior surface of the shaft of the humerus is gently cleared from its muscular and tendinous attachments, great care being taken on the inner aspect to preserve the ulnar nerve from injury during dissection. The olecranon and upper part of the ulna are similarly freed, and the extensor and flexor muscles raised on each side so that both aspects of the elbow-joint are freely exposed. If the ankylosis is fibrous, forced flexion of the joint is usually sufficient to separate the bones, which then project prominently in the operation wound. If the ankylosis is bony in character, the bones are separated by chiselling round the lower end of the humerus. When the bones appear in the wound a thin layer is shaved off the articular surfaces of the humerus, olecranon and head of the radius, leaving a gap of at least three-quarters of an inch between the rough bony surfaces. A wide sheet of fascia lata, which has been removed from the outer aspect of the thigh, is carefully wrapped round the lower end of the humerus and the raw surfaces of the radius and ulna so that all the raw bone is covered, and the covered end of the humerus is then replaced in the enlarged cavity of the olecranon. The operation is now completed by suture of the split triceps muscle and its expansion; active movements are encouraged after the second day, and as a result, a range of about 75 degrees active movement is to be expected.

Excision of the Elbow. A greater range of movement, and a more consistently successful result can be obtained by means of the operation of excision of the elbow-joint, in which a much larger portion of bony tissue is removed, movement subsequently occurring through the fibrous tissue which fills in the gap between the divided bones. The operation, however, has the disadvantage that the lateral stability of the joint is diminished, but where movement is essential, excision is to be preferred in most cases to arthroplasty.

The operation is performed through the same approach as already described for arthroplasty. After clearing the lower end of the humerus and the upper ends of the radius and ulna, the lower end of the humerus

is removed by sawing the bone just above the upper border of the articular surfaces. Through a straight saw-cut the upper end of the radius and the upper part of the ulna are removed at the level of the under aspect of the coronoid process. In order to ensure a successful result, the removal of the bone must be of such extent that, on full extension of the arm without excessive traction, there is a gap of 1½ inches between the divided bone-ends When the correct amount of bone has been removed, and the ends have been smoothed, the triceps and its expansion are sewn back into position, and the arm placed in extension with a moderate pull on the forearm. The object of this extension is the separation of the bone-ends and the prevention of cross-union, which occurs readily if the elbow is placed in flexion directly after the operation.

After 10 days' fixation in extension the elbow is flexed by easy stages, and maintained at a right angle until recovery of active flexion and extension of the joint have been obtained. Active use, gentle massage with supervision, to prevent overstretching of the newly formed long, fibrous ankylosis, *complete the treatment.*

Ankylosis of the Shoulder-joint

Injuries to the region of the shoulder-joint are fully discussed in Chapter V. With ankylosis of the joint the suitable type of treatment depends on the type of ankylosis.

Fibrous Ankylosis. Fibrous ankylosis of the shoulder-joint may follow on any type of infective agent, probably the most common being the tubercle bacillus.

In this joint, operations, such as arthroplasty and excision whose object is the increase of active movement, have no place, and if either of these operative procedures are employed in the shoulder-joint the result is a flail and often painful joint When voluntary movement of the shoulder-joint is lost, a considerable range of useful functional activity can be obtained if the joint is ankylosed in a position of abduction When the joint is fixed in this position the muscles, which normally move on the scapula alone, now act on the *scapula and humerus in one* unbroken bony mass. There are certain essential conditions which must be present before such movement can be utilized:

1. The scapula must not be fixed by extensive adhesions, or fibrosis to the chest-wall.
2. The muscles which act on the scapula must be sufficiently strong to accomplish the extra effort.
3. The angle of ankylosis must be suitable for the age of the patient.

The importance of these first two considerations is quite clear, and in regard to the third, ankylosis of the shoulder-joint in a child may

be allowed to occur at an angle of almost right-angled abduction, whilst in the adult, this angle should not be greater than 50 or 60 degrees with the arm brought forward 10 degrees in front of the plane of the body. The difference of the angle of ankylosis in adult and child depends on the comparative mobility of tissues at different ages. In the child with its looser tissues the excursion of the scapula on the chest wall is much more extensive than is possible with the more rigid tissues of the adult.

When, during the active period of infection in the joint, there is a possibility of ankylosis occurring, the shoulder should be fixed at the suitable angle of abduction on an abduction splint, and maintained uninterruptedly in this position for at least 3-6 months. If, at the end of that period, the ankylosis has become firm, and the tenderness and swelling have disappeared, unsupported use of the limb may be permitted for a short period each day. If, as a result of this test, the angle of abduction has decreased, it is evident that the ankylosis is unsound, and further prolonged fixation may be necessary to convert the unsound into a sound ankylosis.

Usually it is impossible, even by prolonged fixation, to obtain a firm ankylosis when the intervening tissue is fibrous; under these circumstances, if a firm union is considered essential this can only be obtained by arthrodesis, as described in Chapter X. Bony ankylosis is obtained with greater frequency if the combined intra- and extra-articular technique is employed.

Ankylosis of the Wrist-Joint

Ankylosis of the wrist-joint may follow infection, and if firm and painless and confined to the wrist-joint there is comparatively little disability, and little loss of strength in the hand. When the inferior radio-ulnar joint is also involved in the ankylosis the rotary movements of the forearm are lost, and the disability is greatly increased.

Good function following ankylosis of the wrist depends largely on the position at which the joint has become fixed. With the wrist immobilized in palmar flexion, the power of grasp of the hand is diminished, while with the joint fixed in its optimum position of 15 degrees dorsiflexion, the strength of the hand and fingers is at its optimum. It follows, therefore, that if there is a possibility of ankylosis resulting, the wrist must be maintained in this optimum position of 15 degrees dorsiflexion. During the period of fixation by splint or plaster case, complete freedom of movement must be permitted in the metacarpo-phalangeal and inter-phalangeal joints.

Operations to produce bony fusion in the wrist-joint are occasionally necessary following fractures into the joint, or infections. When the operation is undertaken the joint is approached through a dorsal incision, extending over the back of the lower end of the radius, the carpus and

the metacarpals, and through this incision the cartilage is removed from the radius and proximal row of the carpus. This intra-articular fusion should be reinforced by the use of a tibial bone graft, which extends in a deep groove in the carpus from the lower end of the radius into the base of the middle metacarpal. Fusion by means of the bone graft alone may be attempted if there is a great risk of lighting up infection in the ankylosed joint; the operation, although attractive, is not always successful.

Ankylosis of the Inferior Radio-ulnar Joint

Ankylosis of the inferior radio-ulnar joint, with the consequent loss of the power of rotation of the forearm, is a peculiarly disabling condition, which prevents many patients from continuing with their normal work. Relief from the disability can be obtained by removing the lower inch of the ulna, including the articular surface and the styloid process. This operation, which obliterates the action of the inferior radio-ulnar joint, leaves a useful hand with fair stability, but a better

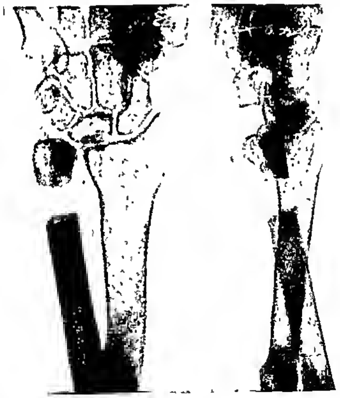


FIG. 15.—Baldwin's Operation

result is obtained by the operation of Baldwin, in which the ligaments of the wrist are not divided.

Baldwin's Operation. An incision is made over the shaft of the ulna, extending from the base of the styloid process 3 inches up the shaft of the bone. After freeing the bone from its muscular attachments, a complete section of the ulna and its periosteum is removed, 1–1¼ inches in length, the lower bone division being one inch above the styloid process. As a result of this procedure the movements, which originally took place at the inferior radio-ulnar joint, are now performed at the un-united fracture of the ulna. The result is excellent, the strength of the hand and forearm being almost equal to normal (Fig. 15).

Ankylosis of the Hip-joint

Ankylosis in Deformity. As in any other joint, the most important single factor is the provision of a useful limb in the angle at which the joint has become fixed. This angle of fixation is not necessarily the same in all patients; if the patient is otherwise normal and the ankylosis sound and unyielding, the ideal position of fixation is 5–10 degrees abduction with 15–20 degrees flexion. The slight abduction allows freedom in walking, and the small amount of flexion deformity is of advantage to the patient in sitting. A greater degree of flexion at the joint is of still further comfort in sitting, but casts a much greater strain on the lumbar spine when the patient is in the erect position.

If the ankylosis of the hip is associated with shortening of the affected leg, an increase in the abduction to 15 degrees, or even 20 degrees, although of advantage in increasing the apparent length of the leg, causes an increased strain on the lumbar spine. It is, in fact, better to compensate for the shortening of the leg by raising the boot on the affected side rather than to throw too great a strain on the lumbar spine and the knee by increased abduction.

There are, however, certain conditions in which we must alter our opinion as to the ideal position of fixation of an ankylosed hip-joint. In generalized infective arthritis of the joint, in which the spine, hips, knees and shoulders become ankylosed, fixation of the hip-joints in extension only causes misery to the patient. It is better to realize under these circumstances that the patient is unlikely ever again to be active, and that he will henceforth be doomed to complete recumbency unless the hips and knees are allowed to ankylose at right angles. If this is done the patient can then sit up, or lie down in comparative comfort, and can get about in a wheel-chair instead of being carried on a stretcher.

The common position of deformity of an ankylosed hip is flexion and adduction, which follows naturally on the over-action of the strong

ilio-psoas and adductor muscles during the period of activity of the disease which produced the ankylosis. The treatment of such deformity naturally depends on the type of ankylosis present. If the ankylosis is sound and unyielding, correction of the deformity by osteotomy, and fixation of the thigh in slight abduction until consolidation is complete, is the ideal treatment. If, however, the ankylosis is unsound, the osteotomy is likely to be followed by recurrence of the deformity and operative fixation of the hip by arthrodesis is then advisable. In the presence of ankylosis of both hip-joints the patient is so inconvenienced that every effort should be made to produce movement at one or other of the ankylosed joints.

Osteotomy. Deformity in the hip-joint can be easily corrected by means of osteotomy, which is performed either through or below the intertrochanteric line. With an acute flexion deformity of the hip it is essential that the line of osteotomy should be placed no lower than the transtrochanteric plane, in order that the upper fragment, which is left in its original position, should not present as a sharp bony prominence under the femoral vessels or the overlying skin.

The ideal osteotomy would be one through the femoral neck—a procedure which was common many years ago but was discarded owing to the frequent occurrence of non-union. When the osteotomy has been performed, as in Fig. 82, two methods of fixation are available, the first, fixation of the limb in a plaster cast at the best angle obtainable. This angle is not usually that of complete correction of the deformity as the soft tissues on the inner side of the limb have become contracted, and can only be lengthened by gradual stretching. The second method has, as its object, the stretching of all the contracted tissues and the complete correction of the deformity. To do this the patient is placed on an abduction frame, the leg is pulled firmly and continuously until the line of the pelvis is straight and the hip is in slight abduction. When this position of complete correction is attained, the patient may be removed from the frame and fixed in a long plaster spica until bony union is complete, walking then being permitted.

With unsound ankylosis the problems to be faced are complicated, and a decision has to be made as to the relative value to the patient of any of the following procedures:

1. Prolonged fixation in plaster.
2. Arthrodesis of the joint.
3. Arthroplasty.
4. Pseudarthrosis.
5. Osteotomy and change of alignment

These problems are fully considered in Chapter VII, and the various considerations expressed there are equally applicable in the case of an unsound ankylosis from any cause.

Ankylosis of the Knee-joint

The problem of limitation of movement of the knee, owing to the presence of adhesions in or round the joint, is discussed in Chapter IV.

Loss of movement may also be caused by muscular shortening, or by the involvement of muscle in a mass of scar tissue, a complication which affects the quadriceps extensor group of muscles more frequently than any other. Here, the muscular mass of the quadriceps is usually bound down to the front of the femur following a compound fracture, or osteomyelitis. The site of fusion between the muscle and the bone becomes evident when an attempt is made to bend the joint passively. As a rule, the adherent scar is so strong that vigorous passive flexion of the joint would result in fracture of the patella, or rupture of the ligamentum patellæ, rather than in restoring movement between the quadriceps and the femur.

If thought advisable the quadriceps may be freed from the femur through a long external incision; when they have been separated, re-adherence may best be prevented by active and passive movements of the joint, which are started the day after operation. The use of a plate of transplanted fascia lata, or fatty tissue between the separated quadriceps and femur, has not proved to be very successful, better results being usually obtained from early movement.

Considerable improvement in the function of the joint can often be obtained by the operation of lengthening the rectus femoris tendon below the point of adherence of the scar. The success of this operation depends on the fact that, as a rule, the scar extends between the femur and the central portion of the quadriceps, the vasti being usually unaffected.

The tendon is lengthened by a Z elongation, the knee-joint being retained in flexion for the first 2 weeks following the operation.

When true ankylosis is present in the knee various points have to be taken into consideration before deciding on the advisability of any operation designed to produce movement in the joint. The operation should never be undertaken when the ankylosis is the result of tuberculous infection of the joint. The risk of lighting up the quiescent disease is so great that no attempt should be made to obtain movement by operation. A sound, painless ankylosis of the knee—whether bony or fibrous in character—is, in most cases, preferable to the condition of a joint in which movement is accompanied by instability. Only in very selected cases, in which for some special reason the patient is very anxious to have movement, should the operation of arthroplasty of the knee-joint be considered. Patients are met with occasionally in whose work movement of the joint is essential, and with them even the

prospect of instability is not of so great importance as the advantages of movement.

Arthroplasty of the Knee. The most successful results of arthroplasty of the knee have been obtained by the use of the technique of Putti. In this operation the joint is opened by a vertical incision above the patella. From the lower end of this incision two curved incisions embrace the upper edge and lateral margins of the bone. The patella is now reflected downwards, still attached to its ligament, and after remodelling the lower end of the femur and the upper surface of the tibia, each of these raw surfaces is covered by a layer of fascia lata. After re-attaching the patella to the quadriceps the wound is sutured, and the knee kept at rest in a slight degree of flexion for 2 weeks. Encouraged active movements are then used to restore movement in the joint, and the success of the procedure depends largely on the ability of the patient to stand the pain caused by these movements in the first few weeks of activity.

Ankylosis of the Ankle

If the ankle-joint is firmly and painlessly ankylosed in good position, no attempt should be made to produce a movable joint. Any limitation of movement at the ankle-joint is compensated by an increased range at the midtarsal and subastragaloid joints. If, however, the ankylosis is unsound and painful, or if a firm ankylosis has occurred at an unfavourable angle, operative correction is necessary. With painful ankylosis, arthrodesis of the joint is advisable, and in the case of ankylosis in a faulty position a corrective osteotomy may be required.

Arthrodesis of the Ankle. The ankle-joint is exposed through a 5-inch dorsal vertical incision along the outer border of the tendons of the extensor longus digitorum; the soft tissues having been retracted, the articular cartilage is removed from the lower end of the tibia, and from the dorsum and sides of the astragalus, together with that of the inner aspect of both malleoli. As an additional stimulus towards ankylosis, an osteotomy of the fibula is performed above the base of the external malleolus, so that this bone may be approximated to the outer surface of the astragalus. The roughened bony surfaces of the tibia and astragalus are now further chiselled and fragmented so as to increase their bone-forming surfaces, and after closure of the wound the foot is placed in a plaster-of-Paris case in the neutral position with the ankle at right angles for a period of 4–6 months. When bony union is complete the patient can walk on the foot without any form of protection, and with a useful, painless foot.

CHAPTER IV

DISABILITIES OF THE KNEE-JOINT

TRAUMATIC SYNOVITIS

When a normal joint sustains a severe strain it responds, as a rule, by the secretion of a large amount of synovial fluid, which distends its cavity and obscures its normal outlines. The increased tension within the joint causes a feeling of discomfort rather than of pain, while the range of movement is diminished to an extent proportional to the amount of fluid present. This increase of fluid is not accompanied by a rise of temperature, either local or general, while at the same time the patient's general condition remains unaffected. The abnormal effusion is the result of a localized hyperæmia, which appears rapidly round a tear or bruising of the synovial membrane, and this increased vascularity remains until the original injury in the synovial membrane has been repaired. The increased synovial effusion is, as a rule, accompanied by a certain proportion of blood which arises from the synovial tear and varies in amount with the extent of the tear.

Differential Diagnosis

Some difficulty may be experienced in distinguishing between traumatic synovitis and hæmarthrosis, which follows a very similar, though usually more severe, injury. Considerable help in making the diagnosis is given by the history of the accident; when synovitis only is present, swelling does not usually appear until 5 or 6 hours after the injury, whilst the distension caused by hæmarthrosis follows almost immediately after the accident. This clinical difference in the time of onset of the swelling is of assistance in distinguishing uncomplicated synovitis from hæmarthrosis, but the greater the proportion of hæmorrhage accompanying the synovitis, the shorter is the interval between the injury and the appearance of the swelling. Palpation also gives assistance in distinguishing between synovitis and hæmarthrosis, the amount of resistance to the examining fingers being much greater in the latter than in the former condition. The diagnosis can always be confirmed by aspiration of part of the fluid contents of the joint, the aspiration being simple and safe so long as strict aseptic precautions are employed.

Treatment

As in the treatment of any other injured or inflamed tissue, rest is essential. It is given most effectively by keeping the patient recumbent for the first few days. The knee should be kept firmly bandaged on a

splint with the joint in a position of slight flexion, the bandage being confined to the region of the joint itself, not extending beyond the upper border of the patella, leaving the circulation of the thigh muscles unimpaired. Voluntary contractions of the thigh muscles without movement of the joint should be encouraged from the first, while massage of the thigh and calf muscles helps the circulation round the knee and promotes absorption of the excess of fluid. Massage of the joint itself should never be employed as it leads to local irritation and delays the full restoration of circulation and function. When walking is permitted the joint should be protected and supported by a firm bandage, the support again being limited to the region of the joint itself, and worn until the atrophied muscles are restored to normal.

CHRONIC SYNOVITIS

A condition of persistent or chronic synovitis commonly results from failure of treatment of acute synovitis, but may also be caused by irregularity of joint surfaces following a fracture, or by the recurring trauma of an internal derangement of the joint. In chronic synovitis the joint is not, as a rule, distended to its fullest capacity but on account of the gross wasting of the neighbouring muscles it may appear to be greatly enlarged in comparison with its fellow. Because of the continued stretching of the capsule and ligaments, there is often considerable instability, while on opening the joint it is found that the synovial membrane is thickened and infiltrated and may even show an unhealed tear in its substance caused by the original injury.

Differential Diagnosis

Chronic synovitis is to be distinguished from:

1. **Villous Synovitis or Chronic Infective Synovitis**, a condition which is usually unilateral, but may on rare occasions be bilateral. In this condition the joint swelling is caused almost entirely by infiltration and œdematous thickening of the synovial lining rather than by the presence of an excessive amount of fluid in the cavity. On palpation, soft, nodular, slightly movable masses can be felt in the supra-patellar pouch, while the range of movement in the joint is diminished by 25 to 40 per cent, while at a later stage definite bone absorption can be demonstrated in the radiograph occurring at the lateral margins of the femoral condyles just behind the articular cartilage.

2. **Tuberculous Synovitis.** The differentiation between simple chronic synovitis and that due to tuberculous infection is often extremely difficult. As a rule, the peculiar doughy thickening of the synovial and perisynovial tissues, which are typical of tuberculous infection, can be recognized, while the radiograph of the joint structures shows a much

more severe and more extensive decalcification than is seen with any other type of joint infection. As in chronic synovitis, pain is seldom present, although there may be more aching round the joint than is present with simple synovial effusion. Occasionally the diagnosis can be made with confidence only by removal and microscopic examination of a portion of the affected synovial membrane.

3. **Syphilitic Effusion.** A swelling of the joint which is always painless and, although in some cases present as a unilateral affection for weeks or even months, it eventually becomes bilateral. The diagnosis is helped by the recognition of other syphilitic stigmata, by the positive Wasserman and Kahn reactions, and by the reaction of the joint to anti-syphilitic treatment.

Treatment of Chronic Synovitis

If either mal-alignment or internal derangement of the joint is present, this must be corrected. The weakened joint should be rested and the atrophied muscles improved in tone, and increased in bulk by massage. Exercises—without weight-bearing—are essential in order to improve control and circulation round the joint, but, as in the case of acute synovitis, massage of the joint itself should never be employed. Occasionally aspiration of the fluid, followed by firm bandage pressure, hastens the absorption, but unless the periarticular circulation is improved by muscle development the fluid rapidly returns.

HÆMARTHROSIS

Hæmarthrosis of the knee-joint, occurring in a patient who is not the subject of hæmophilia, follows usually on a severe twist or blow, or as a complication of a fracture of the articular surfaces of the femur, tibia or patella. On palpation the effusion is firm, the skin over the swelling is darker than normal, whilst the distension of the joint tissues is usually accompanied by a considerable amount of discomfort or even of pain.

Treatment

Rest is essential to prevent any further leaking of blood into the joint cavity, and to reduce the inflammatory reaction which is already present. As absorption of blood from the joint is always a slow and incomplete process, aspiration, which should be as complete as possible, is advisable at an early stage. After removal of the blood the joint should be firmly bandaged, and the routine of muscle development and massage instituted after 48 hours. Active, non-weight-bearing exercises are encouraged after 3 days, unless such movements are contra-indicated by the presence of other injuries, such as fractures, requiring more prolonged immobilization.

DERANGEMENTS OF THE KNEE-JOINT

The strength of any joint depends largely on two factors:

1. The amount of interlocking of the articular surfaces.
2. The strength of its muscle and ligamentous control.

In the knee-joint there is no bony interlocking, and the strength of the joint depends entirely on the muscles and ligaments surrounding it on all sides, and on the two strong intra-articular ligaments which pass obliquely through its centre between the femur and tibia.

THE LATERAL LIGAMENTS

The Internal Lateral Ligament is a complicated fan-shaped *structure, consisting of two fairly distinct portions,* a *superficial* mass, extending from its narrow attachment at the internal femoral condyle to its widespread insertion into the inner side of the shaft of the tibia, about one inch below the articular surface. The deep fibres pursue a much shorter course, being attached to the femur at the same spot as *the superficial fibres, with their lower attachment,* into the postero-internal aspect of the head of the tibia above the insertion of the semi-membranosus tendon On the deep aspect of the ligament some of these short fibres are attached to the subjacent margin of the internal semilunar cartilage.

The External Lateral Ligament is a short rounded cord-like mass, which extends from the upper margin of the fibula to a rough area on the outer aspect of the external condyle of the femur, immediately above the groove in which lies the tendon of the popliteus muscle. The external lateral ligament is not in any way attached to the external cartilage, being separated from it by the synovial covered tendon.

Injuries of the Ligaments

The tension of the lateral ligaments varies considerably with the position of the knee; in full extension the ligaments are under their greatest normal strain, and in this position it is impossible to rotate the joint or to produce any lateral mobility The range of rotation, and of lateral deviation which is normally possible at the knee, increases with the angle of flexion of the joint, until, in a position of full flexion, a considerable range of movement is possible without putting strain on the lateral ligaments. Because of these anatomical arrangements, injuries to the lateral ligaments usually occur while the knee is in full extension, and if these injuries have occurred while the knee is in flexion, the ligamentous tear is generally only part of an extensive and complicated injury.

The severity of the injury sustained by the ligament varies with the amount of force applied; the types of lesion can best be classified under the following headings:

1. Partial tear or strain of the ligament.
2. Strain of the ligament, associated with a lesion of a semilunar cartilage.
3. Tear fracture of a ligament, a flake of bone being pulled by the unbroken ligament from the condyle of the femur, or less frequently from the surface of the tibia or fibula.
4. Complete rupture of a lateral ligament, which is often associated with injury to the crucial ligaments.

Lesions of the Internal Lateral Ligament

Strain or tear of any ligament occurs almost invariably at its attachment to bone, the common site of such an injury of the internal lateral ligament being its femoral insertion. Here, the lesion can be recognized clinically by the presence of acute tenderness, and by referred pain on forced abduction of the leg, or when weight is borne on the limb.

A simple strain of the ligament, in which only a few fibres are torn, does not produce any abnormal lateral movement of the joint, but complete rupture of the ligament—without any other lesion—causes such instability that the leg can be abducted by 20 degrees at the extended knee-joint. Tenderness on pressure over the middle of the internal lateral ligament occasionally follows a strain of the inner side of the knee-joint (Fig. 16). This localized tenderness is not a sign of rupture of the ligament itself, but indicates an injury to its deep fibres attached to the internal semilunar cartilage. When tenderness is present only over this spot in the ligament an injury to the underlying semilunar cartilage should be suspected, although the

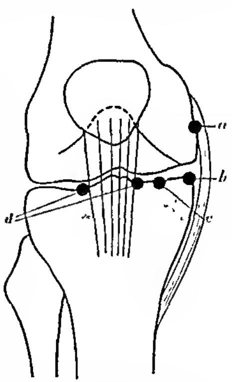


Fig. 16.—Showing points of tenderness round the Knee-joint.

(a) Internal Lateral Ligament Strain
(b) and (c) Damage to Internal Cartilage
(d) Damage to Infra-patellar Pads.

derangement should never be diagnosed without confirmation of other signs and symptoms.

Treatment

The treatment necessary for an injury to the internal lateral ligament naturally varies with the severity of the lesion. There are, however, certain principles which are applicable to all types; thus, strain of the injured ligament must be avoided until the torn fibres have become united. When only a few fibres have been torn the injured ligament should be protected from injury by resting the limb on a splint with the knee in slight flexion. Gentle massage of the whole area should be employed from the beginning, with the object of improving the circulation and diminishing the swelling round the injured area. After 10 days, weight-bearing on the limb can be permitted without strain of the injured ligament. The simplest and most effective method of protecting the internal lateral ligament from strain is by the use of the alteration to the shoe, as described by Thomas (Figs. 4 and 5) With this alteration the patient walks with the foot rotated inwards, thus saving the inner side of the knee-joint from strain, while at the same time the ligament is strengthened by the resumption of function. The altered shoe is retained until the tenderness has disappeared, and until the muscles round the joint have been restored to their normal power and the full range of movement has been regained.

When the ligament has been more severely injured the period of fixation without weight-bearing must be lengthened. The same routine is carried out as for a strain; the joint is fixed on a splint with the knee at 10 degrees flexion, massage and voluntary exercises are encouraged in order to remove the inflammatory swelling. Weight-bearing should not be permitted for at least 4 weeks and, after the resumption of walking, the injured ligament must be protected for a further 6 weeks.

Fig. 17.—Knee Cage.

The prognosis as regards recovery depends largely on the time at which treatment has been started, with early and efficient treatment healing of the rupture is to be expected, but inadequate and inefficient treatment is always followed by great disability, and by persistent laxity of the inner side of the joint. When treatment has been inefficient and the joint is

unstable, considerable support can be obtained by the use of the knee cage (Fig. 17), which allows free flexion and extension, but prevents the abnormal lateral movements. The use of the cage has, however, the disadvantage that it prevents the development of the muscles of the thigh, especially the vastus internus, which normally supports the inner side of the joint. If the cage is not used these muscles can be developed by massage and exercises until they are at least as powerful as before the accident, thereby diminishing the disability and increasing the patient's confidence in the limb.

Operative Treatment of Persistent Laxity of the Internal Lateral Ligament. When the patient is young, and especially when the laxity of the joint prevents him carrying out his normal occupation, it is advisable to attempt by operation to replace the injured ligament. This can best be done by using the lower portion of the semitendinosus tendon as an accessory ligament. With the knee at an angle of 30 degrees flexion the internal lateral ligament is defined through a vertical incision over the inner aspect of the joint. The tendon of the semitendinosus is now freed from its position behind the internal condyle of the femur, and pulled forward until it lies along the length of the internal lateral ligament, which is split longitudinally. At the attachment of the ligament to the femur and tibia deep vertical grooves are cut in the bones; into each of these is placed the semitendinosus, which thus lies in the bony grooves and in the substance of the injured ligament. The tendon is now attached by suture through it and the bony grooves, and the divided ligament is then sewn over the implanted tendon. The knee is retained at the same angle of 30 degrees flexion for a period of 3 weeks, and full movement and muscle control are restored to the joint by a course of non-weight-bearing exercises and massage, extending over a further period of one month.

Lesions of the External Lateral Ligament

Because of the normal obliquity of the femur and of the greater prominence of the internal femoral condyle, injuries of the external lateral ligament are comparatively rare as compared with those of the inner ligament. The usual method of injury of the external lateral ligament is by a forced adduction of the leg on the thigh while the knee is in full extension. As the external lateral ligament is not attached in any way to the external cartilage, injuries of the underlying cartilage are not usually associated with ruptures of the ligament. The site of injury to the ligament is almost invariably its lower end at its attachment to the head of the fibula, and lateral instability following complete and persistent rupture is not so great as that associated with a similar injury of the internal lateral ligament.

Treatment

Treatment of the recent lesion is identical with that employed for a similar injury of the inner side of the joint. Recumbency, protection from strain, development of muscle control by exercises and massage rapidly improve the condition. Simple strain of the ligament causes little disability, and, because of the normal alignment of the limb, even a persisting laxity of the ligament leads to comparatively little permanent disability.

Reconstruction operations, such as that used for the internal lateral ligament, are unnecessary, as the strong ilio-tibial band and biceps muscle can to a large extent replace the action of the torn ligament.

CRUCIAL LIGAMENTS

Of at least equal importance with the lateral ligaments of the knee are the two strong crucial ligaments, which extend through the joint in the intercondylar space between the upper surface of the tibia and the femur. *These intra-articular ligaments are covered by a lining of* synovial membrane, and cross each other almost at right angles in the intercondylar space. By their presence, antero-posterior gliding movements of the femur on the tibia are prevented at any angle in which the joint may be placed.

The anterior crucial ligament is attached to the upper surface of the tibia at the side of the tibial spine and to the intercondylar surface of the external condyle near its posterior edge. The posterior crucial ligament is attached to the surface of the tibia behind the spine, and superiorly to the intercondylar surface of the internal condyle of the femur near its anterior margin. The most important function of the anterior crucial ligament is the prevention of hyperextension of the joint When the knee is fully extended the ligament becomes taut, and hyperextension can occur only if the posterior capsule and the anterior crucial ligaments are torn. The ligament also prevents the sliding forward of the tibia on the femur and acts, to some extent, as a support for the internal lateral ligament. If this ligament has been torn, continuation of the same force of abduction of the leg results in rupture of the anterior crucial ligament.

The posterior crucial ligament prevents hyperflexion of the joint and, at the same time, counters any tendency of the tibia to slide backward *on the lower end of the femur.*

Injuries to the anterior crucial ligament, which usually result from hyperextension of the joint, occur far more frequently than those of the posterior, the latter usually occurring in motor-car or train accidents when force is applied to the front of the tibia while the knee is in right-angled flexion.

Examination. Laxity of the crucial ligaments can usually be demonstrated by the patient; when he stands on the limb it is possible for him, by muscular contraction of the thigh muscles, to push the tibia either backwards or forwards on the lower end of the femur. This abnormal mobility can also be demonstrated by the surgeon grasping the head of the tibia, with the knee bent to right angles, when it is possible to produce the same abnormal movements.

Treatment

Fortunately with most injuries to the crucial ligaments the tear is not complete, and some of its fibres remain as a scaffolding for a new ligament. In every recent injury to one of the crucial ligaments, treatment should be based on the assumption that the rupture is incomplete, and part of the ligament still remains unbroken.

When the injury is diagnosed the affected knee should be fixed for 3–4 months at an angle of 40 degrees flexion in a long plaster case. Although this period may seem to be longer than necessary, an apparent recovery of stability in the joint is often followed by a relapse if a shorter period has been employed. In spite of the rupture being apparently complete the result of treatment is usually good, stability is excellent and muscle control and movements are restored by massage and exercises. The vital importance of persisting with conservative measures can be appreciated from an examination of the unsatisfactory results which usually follow operative treatment, which should only be considered after every effort has been made to restore function by non-operative procedures.

Treatment of Untreated Tears of the Crucial Ligaments. The stability of the joint depends on the two factors of muscle control and ligamentous strength; if the latter has been lost every effort must be made to replace it by an increase of the power of the supporting muscles. If, in addition to an untreated tear of a crucial ligament, there is at the same time poorly developed muscle support, the knee-joint is extremely unstable, and no reliance can be placed on the limb in walking. At each step the tibia slides forwards or backwards on the femur, and walking without the help of sticks or crutches is almost impossible. The control of such a joint can be greatly improved by increasing the development of the muscles of the thigh by a course of exercises and massage. If these muscles can be brought back to their normal size and tone, then the patient's control over the joint is so much improved that he can carry on in most forms of work without any external support.

Where it is impossible to restore the muscles to this state of efficiency the stability of the joint can be improved by the use of the knee cage (Fig. 17) which prevents the antero-posterior gliding of the tibia. By the use of this apparatus the patient is often enabled to carry on his

work indefinitely, but if the joint is already disorganized with osteoarthritic changes, arthrodesis of the knee is the only means of stabilizing the limb and relieving the pain.

Operation for Torn Crucial Ligaments. Many operative procedures have been enthusiastically proposed and tried, but none has proved to be satisfactory. The operations have varied from the suture of the torn crucial ligaments by catgut, silk, or silver wire, to the method of Hey Groves, in which the torn ligament is replaced by a portion of fascia lata. The latter is undoubtedly the best of all the operations, and is carried out by boring through the tibia and the condyle of the femur, the inner opening of these bony tunnels being at the normal point of attachment of the torn crucial ligament. Through these long channels is then threaded a twisted cord-like mass of fascia lata, which is still attached at its lower end. Unfortunately, although the result is good for a time following the operation, the stability of the joint is gradually lost through stretching of the implanted fascia.

INJURIES OF THE SEMILUNAR CARTILAGES

Injuries to the semilunar cartilages are caused through rotation strains on the knee-joint while it is in a position of flexion. In full extension, rotation of the tibia on the femur is not possible unless one of the lateral ligaments has first been torn. Even the most severe lateral strain of the knee-joint in full extension produces simply a tear of the corresponding lateral ligament without causing any injury to the underlying cartilage. If, while the knee is in a position of flexion, the femur is suddenly rotated inwards or outwards on the tibia, the grinding between the bones is sufficient to tear off the attachment of the inner or outer cartilage to the tibia, or more commonly, to cause a rupture in the substance of the cartilage itself This rupture may be a longitudinal split, without detachment at either end, the so-called " Bucket Handle " tear, or the line of cleavage may extend through the inner border of the cartilage, producing the tongue or hinged flap type of injury. The position of the tear depends on the position at which the strain is applied, which in turn is governed by the angle of flexion of the joint at the time of injury. Thus, as a rule, the greater the flexion of the joint at the time of injury the more posterior will be the lesion of the cartilage.

Lesions of the Internal Semilunar Cartilage

The internal semilunar cartilage is injured more frequently than the external. In my own series the proportion has been roughly 5 to 1. In seeking for an explanation of this greater liability to injury of the inner cartilage, the prominence of the inner side of the knee and the difference

between the anatomical arrangements of the inner and outer side of the joint being sufficiently reasonable explanations of the preponderance of injuries to the internal cartilage.

The usual history given by the patient who has suffered such an injury is, that while the foot was fixed and the knee bent the femur was suddenly rotated inwards. This was followed by an acute pain on the inner aspect of the joint and an inability to extend the knee fully. After flexing the joint several times something was felt to slip on the inner side and the knee could then be straightened. The following day the joint was swollen and tender, and remained in this condition for 5 or 6 days. Usually following treatment by rest and massage of the thigh the swelling gradually disappeared, and the knee became apparently normal. As a rule, on subsequent occasions, a similar rotation of the joint was followed by a similar disability and swelling, which was usually less severe than on the first occasion.

Symptoms and Signs

The classical symptoms and signs of a lesion of the internal semilunar cartilage are best classified under the following headings:

1. Pain on the inner side of the joint over the line of the affected cartilage.
2. Tenderness on pressure over the cartilage, and over the middle of the internal lateral ligament.
3. A history of sudden "locking" of the joint, during which the knee cannot be fully extended.
4. Sudden "unlocking" after each "locking," followed at first by synovitis, but later without this sign.
5. Normal radiographic appearance of the joint.

With this classical syndrome there is little doubt as to the diagnosis of an injury to the internal semilunar cartilage, and with repeated attacks removal of the injured cartilage alone should be considered.

There are, however, many lesions of the cartilage which are not accompanied by this classical syndrome of signs and symptoms (Fig. 18). Thus, when the injury is present in the middle or posterior portion of the cartilage the typical "locking" is a mechanical impossibility. This type of injury causes symptoms which are not so definite, and are apparently not so closely related to the lesion in the cartilage. Thus when the tear occurs in the posterior section of the cartilage there is, as a rule, no history of "locking," the patient states that the knee suddenly feels weak and almost gives way, and that on each occasion pain is experienced somewhere in the centre of the joint, but there is no localizing tenderness, and there may be no accompanying synovitis.

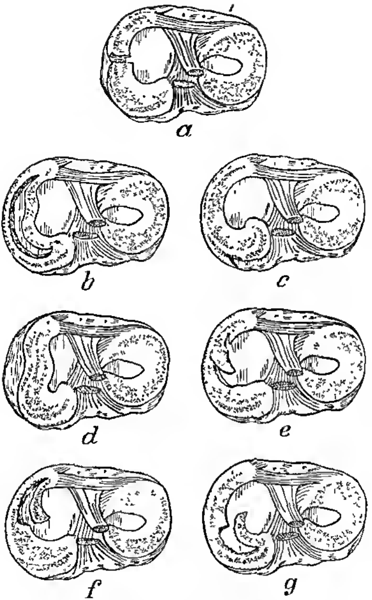


FIG 18—Types of Cartilage Lesion

(a) Transverse Tear in centre of Cartilage.
(b) Bucket Handle Tear
(c) Displaced Posterior Horn
(d) Complete Displacement of whole Cartilage
(e) Complete Tear
(f) Tag of Anterior Horn.
(g) Tag of Posterior Horn

Examination of the Joint

Much can be learned from a carefully taken history of the injury. It is not always possible for the patient to remember the exact angle at which his knee was placed when the strain on the joint occurred, but it is usually possible to decide more or less accurately on its approximate position. The occurrence of pain and its exact site are of considerable importance, while the greatest care must be exercised to diagnose the presence and to localize any area of tenderness. The stability of the lateral and crucial ligaments must be tested, and the full range of painless movement carefully measured. If a limitation of movement is present the cause of the obstruction should be considered. The whole surface of the joint should be palpated whilst the patient bends and straightens it through its fullest possible range. During this examination it is often possible to discover the slipping of a tendon over an abnormal bony prominence, a movement which can produce pain and disability like those of a slipping cartilage.

Radiographic examination of the joint in at least two planes at right angles to each other is of the greatest help in demonstrating that the bony structure of the joint is normal, or that some abnormality is present sufficient to cause the chain of symptoms of which the patient complains.

If in spite of the most careful routine examination the diagnosis is still in doubt, various accessory methods can be employed, of which the following has proved itself to be the most reliable.

This method of examination by manipulation is of particular value in those injuries to the cartilage where the lesion involves the meniscus at, or behind, the middle of the joint. Lesions of the cartilage in this region do not give rise to the classical syndrome of "locking" and "unlocking" because any reduplication of the broken portion of the cartilage produces a block to flexion rather than to extension of the joint. When the test is correctly applied, not only can the presence of a lesion be determined but its exact site can be mapped out with comparative certainty.

In making the examination the patient must be recumbent and relaxed; the surgeon standing on the side of the injured limb grasps the foot firmly, while the knee is bent to its fullest possible range, until the heel approaches or touches the buttock. The foot is now rotated externally, and the leg abducted at the knee. Holding the leg and foot at this angle, the knee is slowly extended. With the alteration of the angle of the joint any loose portion of the internal cartilage is caught between the articular surfaces of the femur and tibia, and the sliding of the femur over the abnormal portion of the cartilage is accompanied by an appreciable click and pain, which the patient states is the same as he has already experienced when the knee gave way. The examina-

tion should be completed by a similar extension of the knee from full flexion, while the foot is rotated inwards and the leg adducted. If no click can be produced by these movements properly conducted it may be safely considered that the internal cartilage is normal posteriorly. If a click is produced it is possible to determine, from its severity and the angle of the joint at the time of its occurrence, the size of the broken portion of the cartilage, and its site in the cartilage substance.

Occasionally when the patient is particularly nervous the examination cannot be properly completed without the help of general anæsthesia.

Differential Diagnosis

If the examination of the knee-joint has been conducted carefully, and the points already described have been noted, there is little danger of a mistake in diagnosis. Occasionally some difficulty is encountered in differentiating the following conditions.

1. **Adhesions.** Following a twist or blow on the front of the joint a localized tear of the capsule, or of the extrasynovial tissues is produced. The injury is followed invariably by hæmorrhagic effusion which becomes organized to form fibrous tissue. This may eventually be absorbed, but may remain as an adherent mass which causes pain when pulled on by rotation of the joint. When this inelastic tissue is stretched by movement of the joint acute pain is complained of roughly at the level of the cartilage, and the patient may state that the knee became "locked" In many instances such a condition of "pseudo-locking" has led to the mistaken diagnosis of injury to the underlying cartilage. The mistake would not be made if it were remembered that "locking" caused by a cartilage lesion is followed by an equally definite "unlocking," while with adhesions the tenderness of the strain gradually diminishes until full movement is restored. Similarly, such extra-articular strains are never followed by the development of synovitis.

2. **Enlarged Post-patellar Pad.** Osteoarthritic changes in the knee, even in the early stage, are usually associated with enlargement of the post-patellar pad; nipping of any portion of this enlarged pad causes a sudden pain behind the patella and its ligament, accompanied by tenderness on both sides of the ligamentum patellæ. As with strain of adhesions, nipping of the post-patellar pad causes only a "pseudo-locking," followed by slow recovery in a knee which, on radiographic examination, shows osteoarthritic changes.

3. ***Loose Bodies.*** These moving freely in the joint may cause symptoms and signs very similar to those of a cartilage lesion; there is the same acute pain and feeling of locking of the joint when the body is caught between the articular surfaces of the femur and the tibia, or occasionally between the femur and the patella, and this may be repeated

frequently. The points on which reliance can be placed for differentiating the two conditions are the variation of the site of obstruction as the loose body alters its position in the joint, and the fact that occasionally the loose body can be palpated in the joint while the radiograph indicates its presence if the body contains bony tissue.

4. Fractures of the Articular Surfaces. Fractures of any portion of the articular surfaces, more commonly of the tibia in the region of the spine, may follow a severe rotation strain of the joint. The knee

FIG. 19.—Fractured Tibial Spine

becomes swollen, tender and full, extension cannot be obtained actively or passively, and the diagnosis of an internal derangement may be reached, but the condition can be readily distinguished by the radiographic appearances (Fig. 19).

5. Osteochondritis Dissecans. Osteochondritis dissecans may be present on the articular surfaces of the femur, tibia or patella, each of which may give rise to clinical signs, which are not sufficiently definite to enable a clinical diagnosis to be made without radiographic confirmation. In many instances there is considerable difficulty in distinguishing

the condition from the other types of internal derangement. When osteochondritis is present in the most typical area on the inner side of the articular surface of the internal condyle of the femur, the patient usually complains of insecurity and of pain in the joint when walking. Exercise is followed by synovial swelling, and when the mass becomes partially or completely detached the patient may complain of a sensation of locking.

These symptoms may suggest the presence of an injured or broken cartilage, but the true diagnosis can usually be demonstrated by radiographic examination.

6. Rupture of the Anterior Crucial Ligament. If the anterior crucial ligament is torn and lies curled up on the upper surface of the tibia, nipping of the ligamentous mass between the femur and the tibia may give rise to a complaint of locking, which is very similar to that given by a patient suffering from a torn internal semilunar cartilage.

Mistakes in the diagnosis of this condition have been comparatively common, but can only arise when the muscular control round the knee is adequate and antero-posterior laxity of the tibia on the femur has been hidden by the good muscular development.

The mistake is easily prevented by the clinical examination when the ligament is tested by pulling the tibia forward on the femur while the knee is held at right angles.

Treatment

The treatment of an injury to a semilunar cartilage must be based on a knowledge of its minute structure and the reaction in its substance which follows on injury. In the substance of the cartilage there are no blood vessels, and if the body of the cartilage is torn there is no tendency towards the ordinary type of healing by fibrous tissue The cartilage cells on the edge of the tear proliferate, but this process never proceeds sufficiently to bridge the gap. On the outer margin of the cartilage, where it lies in contact with the capsule, there is a plentiful supply of blood vessels, and tears and detachments in this area can heal like any other torn tissue by the formation of a hæmatoma which is subsequently organized into fibrous tissue.

After the first injury to the cartilage it is advisable to rest the joint in the hope that the lesion has occurred in the outer vascular area, in which healing can occur if the period of fixation be sufficiently long. The limb should be kept at rest on a straight splint for at least 4 weeks, the knee during all this time being maintained in slight flexion. Wasting of the muscles of the thigh and leg, which would appear rapidly, can be prevented by voluntary contractions of the muscles without movement of the joint. The splint should be retained until all tenderness

and swelling have disappeared from the joint, the normal movements and strength of the limb being restored rapidly by muscle drill and massage.

After repeated recurrence of the displacement, fixation and rest can be of little help, except in so far as they promote a dispersal of the effusion. Fixation for any length of time, in such circumstances, is followed by recurrence of the disability, and removal of the injured cartilage should be undertaken.

Operation. The operation should always be conducted with the help of an efficiently applied tourniquet which is applied high on the thigh after draining the blood from the limb for 3 5 minutes The simplest and most efficient method of removing the cartilage is for the surgeon to sit opposite the end of the operating table, over which the leg hangs free, while the thigh is supported on a sandbag. The seat on which the surgeon sits should be arranged at such a height that he can see clearly to the back of the joint when it is opened. An oblique incision, 1½ inches in length, is made over the antero-internal aspect of the knee, starting below the inner border of the patella, and ending in front of the internal lateral ligament (Fig. 20), the skin, capsule and synovial membrane being divided in the same line. When the joint has been opened, smooth, flat, retractors alone are employed, and no tissue which is to be left in the joint should be clamped or handled by compression forceps.

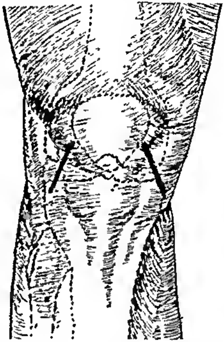


FIG. 20.—Incisions for Operation on Internal and External Cartilages.

If the cartilage tear is situated posteriorly the joint may appear normal, but if the condition has been correctly diagnosed before operation the surgeon can, with confidence, proceed to remove the whole meniscus. A blunt hook is placed below the cartilage, and its anterior attachment is divided close to the tibia; continuing the separation backward, the cartilage is freed completely from the anterior portion of the capsule and from its attachment to the internal lateral ligament. If this separation has occurred at the correct line no difficulty is experienced in pulling the whole body of the cartilage into the intercondylar space,

as its attachment posteriorly to the capsule consists only of a small amount of loose areolar tissue. The knee is then flexed further and tension is applied to the displaced cartilage to pull forward its posterior attachment, which is cut through vertically by a tenotomy knife held in the intercondyloid fossa. When the whole of the injured cartilage has been removed, the synovial membrane, the capsule and the skin incision are sewn separately, and over the dressing is applied a large quantity of sterile wool which is firmly bandaged over the whole joint. This post-operation compression is the most effective method of preventing reactionary swelling or hæmarthrosis, which might complicate the operation and prevent full recovery. Following the operation the limb should be retained at rest on a splint for 10 days, during which the patient remains in bed, and after removal of the stitches a shorter splint should be applied for another week when walking is resumed.

During the period of rest in bed, and after the resumption of activity, the patient must be encouraged to exercise the muscles of his thigh, especially the quadriceps, which would otherwise waste as a result of the inactivity. Following removal of the splint a bandage should be applied round the joint until full recovery of power has been secured by voluntary exercises and massage. This apparently protracted fixation of the joint does not tend to produce stiffness, but permits sound healing and consolidation of the scar in the capsule. Athletic games can usually be resumed in 6 weeks, and no subsequent disability is to be expected if the whole of the affected cartilage has been removed.

Removal of the Posterior End of the Internal Cartilage. If the whole of the injured cartilage has not been removed the patient often complains of a feeling of instability in the joint. "Locking" does not usually occur, but athletic games cannot be enjoyed because of the feeling of insecurity. As a rule, the patient states that when running or twisting on the joint there is a momentary feeling of uselessness in the limb, accompanied by a sudden pain in the region of the knee. He cannot localize the site of the pain, and there is at most very slight tenderness in the posterior aspect of the joint at the cartilage level. On manipulation it is usually possible to demonstrate that a portion of cartilage is still present posteriorly, and the patient states that the feeling produced on manipulation is the same as that experienced on exercise.

Under these circumstances removal of the remaining portion of cartilage is necessary. The removal is easily completed through a small vertical incision between the internal lateral ligament and the inner hamstring muscles with the knee at right angles (Fig. 21). In this position the hamstring muscles lie posteriorly, and the incision can be carried straight down through the capsule and synovial membrane. The remaining portion of cartilage is freed anteriorly from the internal

lateral ligament and, after separation from the capsule, its posterior attachment to the head of the tibia is divided by a tenotomy knife.

After-treatment is identical with that employed after removal of the whole cartilage.

Manipulative Treatment for Cartilage Injuries. Manipulation has been employed from time immemorial as a method of treatment for lesions of the semilunar cartilages. Instances of so-called cure by this method are quoted, but a detailed study of the history given by the patients so treated indicates that the injury of the joint was probably not a true lesion of the cartilage. If adhesions are present in the joint

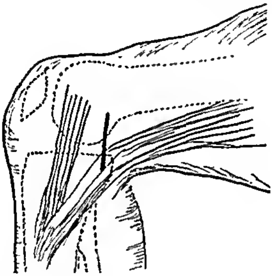


FIG. 21.—Incision for Posterior Horn of Internal Cartilage.

area, following a strain or bruise of the synovial or perisynovial tissue, any rotary movement of the knee is followed by an acute pain referred to the injured area. Because of this the patient cannot straighten the joint, and a mistaken diagnosis of cartilage lesion is often made. If manipulation is employed for the treatment of adhesions cure is to be expected, but when this method is used for the treatment of a true cartilage tear the result is always unsatisfactory.

Manipulation. Under full anæsthesia the knee is bent to its full range and slowly straightened, each few degrees of straightening being accompanied by rotation of the leg, internally and externally, to its full extent. After the manipulation some tenderness may remain if firm adhesions have been torn, but full painless function is usually regained in a few hours following free use of the joint.

EXTERNAL SEMILUNAR CARTILAGE

Although occurring less frequently than with the internal, injuries of the external cartilage are more common than is generally recognized. The types of injury found in the external cartilage are almost identical with those of the internal and in addition severe disability is caused by the occasional presence of a congenital abnormality in the structure of the external cartilage, a condition which has been seen on only one occasion in connection with the internal cartilage.

During the early part of fœtal life the cartilages are represented by a complete plate of mesodermic tissue, lying between the femur and tibia. The plate becomes divided into two parts by the growth forward of the crucial ligaments. Gradually absorption of the centre of each

FIG. 22.—Congenital Discoid Cartilage.

cartilage occurs, leaving the typical quarter-moon shape. Occasionally, in the external cartilage, this absorption does not occur, or does not progress to its full extent, so that the cartilage is left as a complete disc, separating the femur from the tibia (Fig. 22), the abnormal mass causing pain and weakness in the joint, whose movements are accompanied by a peculiar loud noise. A joint in which such a congenitally abnormal cartilage is present can easily be recognized by the occurrence in a child of this loud noise on movement, and by a distinct feeling of slipping or gliding on the outer side of the joint.

Tears of a discoid cartilage occur frequently. The line of injury in the meniscus runs from the firm inner border into the substance of the cartilage, and the increased disability which follows the tear usually forces the patient to have the abnormal cartilage removed.

The usual cause of failure to recognize injuries of the external cartilage

is to be found in the fact that a rupture or displacement of this cartilage produces a much less definite chain of symptoms than in the case of a similar injury to the internal cartilage. Thus, locking is common with lesions of the internal cartilage and rare with those of the external. Pain and tenderness are not so constant as in the case of lesions of the internal cartilage, and subsequent displacements are not, as a rule, followed by synovitis of the joint.

The usual story is that the knee gives way suddenly with a feeling of weakness or slipping on the outer side, followed hy slight tenderness on pressure over the posterior part of the cartilage or external lateral ligament. Accompanying this there is often a loud "click" or "clunk," which can be felt and heard, occurring most typically in the last few degrees of active full extension of the joint, but not being recognizable when this movement is carried out passively. Additional evidence as to the presence of the lesion can usually be elicited by the method of manipulation of the joint described in the case of lesions of the internal cartilage, with the difference that on examination the foot is rotated inwards, while the leg is adducted at the knee during the examination.

Treatment

When the diagnosis of displaced, or torn, or congeoitally mal-formed external semilunar cartdage has been made, conservative treatment is of little help, and removal of the offcoding cartilage should be carried out. The operation is performed in a similar manner aod with the same precautions as for an internal cartilage, always remembering that the whole of the affected cartilage should he removed. The disability which is caused by leaving a portion of the external cartilage in the joint is very similar to that found in connection with the inner cartilage. There is the same feeling of weakness and instability, the tenderness, when present, being behind the external lateral bgament. The presence of the fragment can be confirmed by manipulation of the joint, and relief can he obtained only by removal of the retained segment.

Removal of Posterior End of External Cartilage. The operation for removal of the posterior end of the external cartilage is not so simple as that on the inner side of the joint; with the knee flexed to slightly more than right angles a vertical incision, 3 inches in length, is made behind the external lateral ligament, and in front of the hiceps tendon which has fallen backwards. At the bottom of this wound the capsule is opened, and lying directly anderneath is seen the tendon of the popliteus muscle. This smooth, shining, synovial covered mass lies parallel with the upper surface of the tibia and, on many occasions, the tendon has been removed in mistake for the cartilage, which lies at a deeper level. The tendon should be retracted downward, when it

is comparatively simple to recognize and remove the posterior portion of the external cartilage from its tibial attachment.

The after-treatment is carried out exactly as for the other cartilage operations, and no special precautions are necessary.

Disabilities after Removal of the Semilunar Cartilages

1. *Mistake in Diagnosis.*

2. *Removal* of the uninjured cartilage.

3. *Weakness of the Knee-joint*, due to wasting of the thigh muscles, and usually the result of faulty after-treatment.

4. *Recurrent Synovitis*, which is usually caused by an unnecessarily extensive incision into the synovial membrane, or occasionally trauma to the post-patellar pad at the time of operation.

5 *Reappearance of Symptoms* originating in the removal of only a portion of the affected cartilage, the rim or posterior horn which was left causing slipping and apparent locking, and requiring subsequent removal.

6. *Ankylosis* following infection, the greatest avoidable tragedy in the surgery of the knee-joint.

CYSTS OF THE SEMILUNAR CARTILAGE

Cystic formations are occasionally found in association with the semilunar cartilages, more frequently with the external than with the internal. When present, they are seen as rounded, tender swellings, varying in size from a bean to an orange, and occasionally of almost bony hardness, situated, as a rule, close to the external or internal lateral ligaments. The tumour can usually be seen when the knee is bent, but becomes more prominent and much more tense when the joint is fully extended (Fig. 23).

Fig 23.—Cyst of the External Semilunar Cartilage.

The nature of these cysts has long been a subject of debate, and there are two main theories in regard to their origin:

1. That they are congenital in origin with a lining wall consisting of flattened endothelial cells.

2. That they are the result of myxomatous degeneration of cartilage cells, the lining wall being composed of flattened cartilage cells which take the appearance of endothelium.

Most surgeons take the latter view of their origin, as definite new blood vessels can be demonstrated in the region of the cyst formation and, as blood vessels are normally absent from cartilage tissue, it is probable that the cysts arise in an injured area in which the cartilage cells undergo degenerative changes.

The patient usually complains of chronic, aching pain, which he describes as toothache. This is made considerably worse by weight-bearing, but never completely disappears, even with rest, while symptoms of true internal derangement, such as locking and unlocking of the joint, are never present unless the cartilage itself has also been broken. These cysts are always multiple in structure and prolongations can be found extending into the substance of the affected cartilage.

Differential Diagnosis

Cysts of the semilunar cartilage must be distinguished from cysts arising from the synovial membrane of the joint. These are not, as a rule, so tense as the cyst arising from the cartilage; they do not cause the chronic, aching pain which is characteristic of the former and they do not alter in size or tension with changes in the position of the joint.

Treatment

Local removal or aspiration of the cyst, although causing a reduction in size of the tumour, is always followed by recurrence, and the only satisfactory treatment consists in removal of the whole of the affected cartilage.

LOOSE BODIES IN THE KNEE-JOINT

Loose bodies occur more frequently in the knee than in any other joint. Their structure varies very greatly, but the symptoms to which they give rise differ very slightly with the different types of loose bodies.

Structure of the Bodies usually found

1. *Fibrinous*—soft, structureless masses composed of fibrinous material and found after hæmarthrosis or infective synovitis.

2. *Fibrous*—which originate in one of the villi of the synovial membrane, forming a mass at first pedunculated and later free.

3. *Cartilaginous*—formed by separation of part of a meniscus, or of a portion of articular cartilage.

4. *Osteo-cartilaginous*—originating in the detachment of a portion of the articular surface, and consisting of a cortex of cartilage and fibrous tissue with a centre of bony material.

5. *Sequestrum*—found usually in association with tuberculous arthritis.

FIG. 24.—Osteochondritis Dissecans of Internal Condyle of Femur.

The majority of loose bodies belong to the cartilaginous or osteo-cartilaginous groups, and in the latter is found the most typical example of the classical loose body in the condition known as osteochondritis dissecans (Fig. 24). Here the body may lie loose in the joint, or may be adherent by a hinge to the area from which it is being detached

The condition may be found in any part of the articular surfaces of the femur, tibia or patella, although most commonly seen on the articular surface of the internal condyle of the femur, usually towards the inter-condyloid notch; the loosened area of cartilage is more or less circular and varies in size from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch in diameter. A portion of the underlying condyle is adherent to the loose cartilage, and with it forms the loose body, the bony tissue being usually much smaller than the

cartilaginous portion. It has been suggested that this wedge-shaped mass of bone and cartilage becomes detached because of the closure of an end artery cutting off the local blood supply, but this explanation cannot be supported, as end arteries are not present in this area and it is more probable that the detachment follows a hæmatoma, caused by injury, which acts in the same way.

Symptoms and Signs

A loose body, or even a number of loose bodies, may be present in the knee-joint for many years without giving rise to any discomfort or

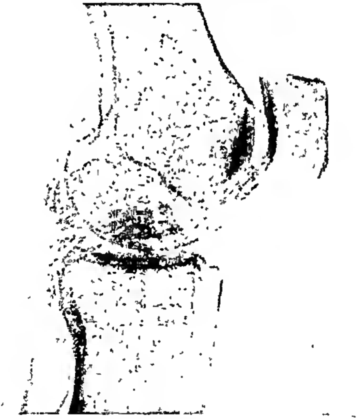


Fig. 25.—Loose Bodies in Knee.

disability. Frequently the first sign of trouble is a sudden locking of the joint, due to nipping of a loose body between the femur and tibia, or between the femur and patella. With a certain amount of wriggling the patient can usually get the body out of the way and the joint seems

normal, although somewhat sore. This first attack is almost invariably followed by synovitis, but subsequent lockings produce less swelling. Occasionally the surgeon or the patient may be able to localize and feel the loose body at one of the more accessible areas of the joint. Usually, sooner or later, the locking is repeated and, in the typical instance, the site of locking is now in some other portion of the joint.

An X-ray photograph may show the presence of several loose bodies as definite bony masses, or, in the case of a hard, fibrous or cartilaginous body, may suggest the presence of such an abnormality, particularly when the photograph has been taken with specially "soft" X-rays (Fig. 25). Occasionally a loose body, which has given rise to discomfort and frequent lockings, may apparently disappear and cause no further trouble. Such a cessation of symptoms usually follows the attachment of the body to the capsule of the joint in a position where interference with joint movements is impossible.

Treatment

When one or more loose bodies are present in a joint and are giving rise to trouble, the question of operative removal must be considered. If the joint is otherwise healthy, and there are no contra-indications, then removal of the loose bodies should be urged with confidence. If, however, the joint is the seat of an extensive osteoarthritis, removal of the loose bodies, although necessary, can at best result only in a partial relief of symptoms.

Conservative Treatment. In the small percentage of cases in which operation of any type is refused, fixation of the joint for a period may result in the attachment of the loose body in an area, such as the supra-patellar pouch, where locking is impossible. The result of such treatment is so uncertain, and the risk of stiffness following prolonged fixation so great, that operation is usually preferable.

Operative Removal. The operation for removal of a loose body from the knee-joint may be one of the most tedious and difficult procedures in surgery. When the joint is opened it is natural that a movable body should fall to the lowest possible point. The method of opening the joint more and more widely to get a better view leads to unnecessary trauma and often results in failure. If it is possible to bring the loose body into the line of the incision, tissue injury is avoided. Two methods are available. The first consists in an attempt to float the loose body by filling the joint with saline, using a Higginson's syringe, through which saline is forced into the knee. The second by massaging the body into the area of the wound, from which it can easily be removed.

A small vertical incision is made at the upper and outer border of

the patella. With the knee slightly bent, the synovial membrane is opened in the line of the incision, and the whole joint, which has previously been covered by a sterile cloth, is massaged towards the incision. Any body, which is really loose and is situated in the anterior compartment of the knee, can be satisfactorily dealt with in this way. Small loose bodies situated in the posterior part of the joint can also be manipulated through the intercondylar notch, but if their size prevents such movements, they should be removed through a vertical incision made over the appropriate lateral margin of the joint with the knee bent to right angles. At this angle the hamstring muscles have fallen backwards, and the incision does not then involve any important structure, while sufficient room is obtained for dealing with the whole compartment.

RECURRENT DISLOCATION OF THE PATELLA

Without rupture of its ligament the patella may dislocate to the outer or inner side of the limb, and on rare occasions may rotate vertically so that its border—usually the outer—is caught in the intercondyloid notch of the femur. Recurrent dislocations of the bone only occur towards the outer aspect of the femur; if the bony and muscular structures round the joint are normal, recurrent dislocations are uncommon, but, in the presence of abnormal bony development or of unhealed tears in the quadriceps expansion on the inner side of the knee, displacement of the patella may occur each time the joint is flexed. The factors which predispose to the recurrence of the displacement are:

1. Want of development of the external condyle of the femur, either as a congenital deformity, or as the result of rickets or trauma.
2. Overgrowth of the internal condyle from similar causes.
3. Knock-knee deformity, in which displacement of the patella to the outer side tends to occur owing to the pull of the quadriceps.
4. Traumatic dislocation recurrence.

Of these the knock-knee deformity is the most common cause of recurrent displacement in the young adult. The deformity may be present as the sole predisposing cause of the displacement, or it may be combined with depression of the external condyle.

Signs and Symptoms of the Displacement

As a rule, the patient complains of a sudden giving way of the knee, especially when weight is borne on it in a position of flexion. This yielding is accompanied by an acute pain over the front of the joint, and voluntary extension of the limb is found to be impossible. Usually before medical help arrives the joint is straightened and the patient

may not be able to describe exactly the condition present. These signs simulate those of locking produced by displacement of a semilunar cartilage, but the correct diagnosis is indicated by the excessive lateral mobility of the patella with the knee in the extended position.

Treatment

Conservative. If the displacement has been caused by a mild degree of knock-knee, accompanied by a loss of tone of the muscles, exercises and massage of these muscles, especially of the vastus internus, may be of considerable help and should diminish the tendency to recurrence, but in the presence of a severe knock-knee, or of a definite congenital flattening of the external condyle, more radical treatment is necessary.

Operative. Most of the younger patients can be successfully treated by femoral osteotomy, in which the deformity of knock-knee is slightly over-corrected. The pull of the quadriceps is now more over the internal condyle, thus tending to prevent the slipping outwards of the patella.

In those cases where the limb is straight, and where no definite congenital deformity of the external condyle can be demonstrated, the operation of Goldthwait is the most suitable.

Goldthwait's Operation. A long incision is made on the outer border of the patella, sweeping downwards across the insertion of the ligamentum patellæ. This tendon is exposed and split into two equal parts from the tibia to the lower border of the patella. The outer half is erased from its insertion, or preferably removed with its bony attachment, and passed under the inner half, which is left attached in its normal position. The fascia lata on the outer border of the patella and on the outer aspect of the thigh is split on the line of the incision so that the patella may be pulled inwards without excessive tension (Fig. 26). A deep slot is now made on the inner aspect of the tibia into which the transplanted outer half of the tendon is inserted with its bony attachment. Fixation at rest for 6 weeks, followed by exercises, is sufficient to promote firm union, when the normal functions of the joint may be permitted with safety.

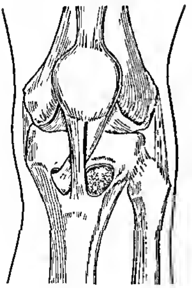


FIG. 26.—Goldthwait's Operation for Slipping Patella.

Transplantation of the whole of the Ligamentum Patellæ. A more successful realignment of the pull of the quadriceps on the tibia can be obtained by the transference of the ligamentum patellæ with its bony attachment into a new site on the inner surface of the upper end of the tibia. The operation is similar to that of Goldthwait without the splitting of the ligament. Through the same incision the tissues on the outer aspect of the patella are freed, and the ligament with its attached portion of tibia removed and implanted into the tibia $1\frac{1}{2}$ to 2 inches further internally. The after treatment is the same as for the previous operation and the result is usually more satisfactory.

Removal of the Patella. Constantly recurring dislocation of the patella leads eventually to the development of arthritis of the joint, the bony changes first appearing between the patella and the femur with the involvement of the whole articulation at a later date The repeated trauma, which maintains and increases the arthritic changes, can best be avoided by removal of the patella, the loss of this bone causing comparatively little disability or loss of strength.

Through a transverse incision the patella is dissected from its tendinous attachments and removed, after dividing the synovial membrane as close to its articular surface as possible. When the bone has been removed great care is taken to close the synovial cavity completely, so preventing adhesions which would otherwise form in the joint. The quadriceps tendon is then sutured to the ligamentum patellæ, and any cuts in the lateral expansions are treated by suture or overlapping. After skin suture the limb is fixed slightly bent on a splint for 2–3 weeks. Non-weight-bearing exercises are started early, and after 4–6 weeks weight may be taken on the limb without danger.

The results of this operation are excellent, and in the presence of arthritic changes in the joint it is to be preferred to any other form of operative treatment.

CHAPTER V

INJURIES TO THE SHOULDER-JOINT

The strength and stability of the shoulder-joint depend on the ligaments and muscles which surround it and govern its movements. Because of the absence of bony interlocking between the humerus and the glenoid cavity of the scapula, strains are borne on the muscles and ligaments rather than on the articular surfaces of the joint. Traumatic synovitis or arthritis occur in the shoulder as in any other large joint, and give rise to signs and symptoms typical of these conditions, but, on account of the frequency of extra-articular injury in this region, a special description of the conditions commonly found and of their appropriate treatment is of importance.

The shoulder region may be injured either directly by a blow on its surface, or indirectly following a fall on the outstretched hand, the force being transmitted along the forearm and arm-bones to the joint tissues. In either case the trauma is usually followed by limitation of movement, the cause of which is often hard to determine. If the radiograph demonstrates the absence of bony injury the rigidity may be due, either to traumatic arthritis of the shoulder-joint, or to bruising or tearing of the periarticular tissues, followed later by the formation of periarticular adhesions. These two conditions between them constitute the majority of the soft-tissue injuries of the shoulder region, their importance depending on their similarity of clinical signs, and on the fact that treatment of the two conditions is so essentially different.

The signs of the two conditions can be summarized easily under the following headings.

	Periarticular Adhesions	*Traumatic Arthritis*
1	Rigidity follows trauma in 2-3 days.	Rigidity follows trauma in 2-3 weeks.
2	No radiographic changes.	No radiographic changes
3.	Small range of clear movement, usually with arm adducted.	No clear range of movement.
4.	No tenderness on pressure over joint.	Tenderness on pressure, usually over bicipital groove
5.	Patient can usually sleep on affected side	Patient cannot sleep on affected side.
6	Little or no pain except on passive movement.	Aching pain, usually slight, most of the time.
7.	Use does not alter the symptoms.	Pain is definitely increased by use.
8.	Pain and tenderness immediately relieved by rest.	Discomfort or pain not completely obliterated by rest.

Treatment of Periarticular Adhesions

The prevention of the formation of adhesions is usually comparatively simple. Following a bruising of the joint voluntary movements should be encouraged from the first, and gentle massage given to the whole region, with the object of dispersing any exudate and preventing fibrosis of the ligaments and tissues. If adhesions are already present the treatment should depend on their severity. If of recent formation full movements can usually be restored by gentle stretching, combined with massage and active movements.

When the adhesions have been present for a long time and are rigid and unyielding, movements of the joint can be restored only by the help of manipulation under anæsthesia. The use of full anæsthesia is of the greatest importance, as in its absence it is impossible to judge how much of the resistance is caused by adhesions and how much by protective muscle spasm.

Treatment of Traumatic Arthritis

Rest of the inflamed joint is essential and should be continued until the arthritis has become quiescent. The arm should be slung by the side, care being taken to prevent further injuries to the region. During the waiting period the aching in the shoulder gradually diminishes, tenderness disappears, the patient discovering that it is possible to sleep on the affected side without causing pain, while digital pressure over the bicipital groove can be borne without discomfort. Rest is continued until all signs of inflammation have disappeared from the joint. This stage is usually indicated by the patient's statement that the pain on attempted movement, which was previously present over the joint, is now situated at the insertion of the deltoid muscle. At this stage, and not before, manipulation of the shoulder, with the object of breaking down adhesions, should be carried out exactly as in the case of periarticular adhesions, with a similar line of after-treatment, and with excellent prospects of complete recovery of function.

Manipulation. Manipulation of any joint should be carried out carefully under a definite plan, each movement being completed fully with adequate protection of the joint against injury or dislocation. With the assistant's closed fist pressed into the axilla, in order to prevent dislocation of the head of the humerus, the arm is grasped above the elbow and abducted to the full range (Fig. 27). As the range of possible abduction is not constant the normal extent of the patient's movement can best be judged by raising the other arm to its full extent. The shoulder is then rotated outwards and inwards, the very greatest gentleness being used in this latter movement, as fracture of the neck of the humerus may easily occur if it is performed jerkily or beyond the normal

limits. After the manipulation the patient lies in bed with the arm abducted to the horizontal plane, and the shoulder rotated outwards. Massage of the shoulder and encouragement of active movements is usually sufficient to retain the movement gained at the time of opera-

FIG 27.—Manipulation of the Shoulder, showing assistant's fist supporting the head of the Humerus and surgeon's hand steadying the Scapula

tion So long as tenderness remains, active full abduction is impossible. The range of abduction can, however, be maintained by the exercise known as "Climbing up the Wall,' in which the patient creeps with the fingers of the affected hand higher and higher, whilst the side is pressed against the wall, thus increasing the abduction

Restricted Manipulation. A full manipulation as already described is usually impossible when the restriction is present in a healed traumatic arthritis. When operating for this condition, it is found that the resistance is so great that a fracture of the neck or shaft of the humerus would occur before the full range has been obtained Under these circumstances only a limited range of movement should be attempted on the first occasion Later this procedure may be repeated and a greater range obtained.

LESIONS OF THE SUPRASPINATUS TENDON

Following a severe strain, or dragging of the arm, the delicate tendon of the supraspinatus muscle may be partially or completely torn close to its attachment to the head of the humerus. Although the lesion occurs under cover of the large mass of the deltoid muscle, its occurrence can be recognized by the loss of the movement which is normally produced by the action of the supraspinatus muscle. The first 10 to 15 degrees of active abduction of the arm are carried out solely

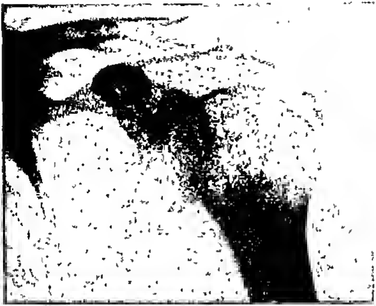


Fig. 28.—Calcareous deposit in Supraspinatus Tendon.

Fig. 29.—Same patient 3 weeks later after rest in abduction arm frame.

by the supraspinatus muscle, no other muscle taking part in this action.

Following the injury abduction of the arm from the side is painful or impossible for the first few degrees, but as soon as the arm is passively abducted by 30 degrees the movement is strong and almost painless. Similarly, whilst the arm is being slowly lowered from a position of abduction, movement is free and controlled until the angle of 30 or 40 degrees abduction is reached, after which control is lost and the arm falls to the side. Tenderness on pressure is present over the outer aspect of the great tuberosity, just under cover of the acromio-clavicular joint, but on abduction this tender area passes under cover of the acromion and tenderness cannot then be demonstrated.

Type of Injury. In most instances the lesion consists simply of a strain at the insertion of the tendon into the humerus, causing a localized inflammation and loss of function. Occasionally, following the strain, a deposit of calcified material forms close to the insertion of the tendon into the bone, giving rise in the radiograph to a suggestion of tear fracture (Figs. 28 and 29). Owing to the close connection between the tendon of the supraspinatus and the capsule of the shoulder-joint, complete rupture of the tendon is always accompanied by an extensive hæmorrhagic effusion into the joint cavity.

Treatment

Fixation of the arm in a position of abduction, combined with heat or gentle massage, for a period of 3–4 weeks, generally results in a disappearance of the pain, and is also in most instances followed by disappearance of the calcareous mass, when this is present. With complete rupture of the tendon such conservative measures usually result in an improvement in function but never in a complete restoration of the previous power. If the disability resulting from the rupture is sufficient to interfere with the patient's normal activities, an attempt should be made to suture the divided tendon by open operation.

RUPTURE OF THE LONG HEAD OF THE BICEPS

This injury occurs comparatively frequently—as a rule in men over 40 years of age—especially where osteoarthritic changes are present in the joint and in the bicipital groove. The rupture (Fig. 30), which is the end result of the constant fraying of the tendon in the roughened bony tunnel, occurs in the substance of the tendon and not, as is usual in other similar ruptures, at the musculo-tendinous junction.

The signs are clear; on attempts at flexion of the elbow a distinct gap can be felt on the upper and inner side of the muscle mass which lies at lower level than normal. At first most of the power of

flexion is lost, but after a few months, even without restoration of the continuity of the divided tendon, the function is almost completely restored.

Treatment

If the patient is seen directly after the occurrence of the rupture, an attempt should be made to join the divided tendon, or to suture its lower portion into the shaft of the humerus in the region of the bicipital groove. This helps to maintain the normal appearance of the arm and retains most of the strength of the muscle.

When the injury is of long standing the function of the arm is usually so good that operative interference is unnecessary.

Fig. 30.—Rupture of the Long Head of the Biceps.

TENO-SYNOVITIS OF THE LONG HEAD OF THE BICEPS

This disabling condition usually follows on long-continued heavy work. It is diagnosed by the presence of pain, tenderness and swelling over the course of the affected tendon. All these signs are increased in severity when the muscle is contracted against resistance. Fine crepitus can occasionally be felt along the course of the tendon when the muscle undergoes active contractions.

Treatment

Rest for 3 weeks with the elbow at right angles until the symptoms disappear, followed by an increasing range of active use of the arm, will usually cure the condition.

SUB-ACROMIAL BURSITIS

The presence of a true bursa in the sub-acromial region has been questioned, and it is probable that, following injury, the bursa develops from expansion of one or more spaces in the loose areolar tissue under the deltoid. Inflammation and tenderness in this area occur frequently and give rise to symptoms and signs which are often difficult to differ-

entiate from those of supraspinatus injury, or arthritis of the acromio-clavicular joint.

Enlargement and inflammation in this bursa is characterized by tenderness over the outer side of the joint, just below the acromion process. This tenderness is not so localized as that present following injury to the supraspinatus tendon; it can be elicited on pressure at any point close to the outer border of the acromion process, and it is present in all positions of adduction or abduction of the arm. In addition to the tenderness on pressure, pain is caused by active contraction of the deltoid muscle, the pain occurring as soon as this muscle comes into use. Occasionally the bursa becomes greatly enlarged, causing distension of the whole of the shoulder girdle and appearing as a smooth, rounded projection from the anterior margin of the deltoid muscle.

Treatment

In the acute stage, in which the bursa is extremely tender, rest of the arm in abduction, combined with the application of heat and gentle massage, cause a rapid improvement in the condition and a disappearance of the disability.

When the bursa is greatly enlarged and thickened it should be removed through a vertical incision along the anterior border of the deltoid.

RECURRENT DISLOCATION OF THE SHOULDER-JOINT

If, after the reduction of a simple dislocation of the shoulder-joint, the arm is kept at rest for 2 or 3 weeks to allow the torn tissues to become united, a subsequent dislocation usually occurs only when an equally severe injury has been sustained. Without this necessary period of rest, and occasionally in spite of it, recurrence of the dislocation may follow slight injury The cause of the recurrence may be a congenital deformity of the glenoid cavity, or an abnormality of the articular surface of the head of the humerus, but the explanation is most probably the presence of an untreated tear in some portion of the joint capsule. These redislocations usually follow some slight movement of the arm, whilst in a position of abduction. On the first occasion there may be difficulty in reducing the dislocation, but on each displacement reduction becomes easier, and eventually the patient can reduce it by rotation.

Many suggestions have been advanced to explain this tendency to displacement. Thus, laxity of the capsule, especially in the floor of the joint, whilst invariably present, could not of itself be responsible. Bankart has shown that an unrepaired tear of the attachment of the orbicular ligament to the glenoid cavity in its anterior portion can always be demonstrated. Perthe has stated that in recurrent dislocation

of the shoulder a bony lesion of the lower border of the glenoid cavity is always present.

Treatment

Treatment of the condition can be conservative or operative.

Conservative. The control of the joint during athletic pursuits can be improved by the wearing of a check strap. This consists of two loose leather loops, one round the body and the other round the arm; these are joined together by means of a strap passing through a hole in the coat and in the sleeve. By preventing abduction of the humerus the tendency to dislocation is eliminated and the patient can carry on suitable athletic pursuits with confidence and safety.

Operative. The simple operation of reefing and suture of the capsule, usually performed through an axillary incision, has proved to be entirely unreliable and should never be performed.

Although many operative procedures have been described and practised, the results obtained by Bankart's operation are so consistent that this procedure should always be adopted.

Bankart's Operation. The shoulder is approached through a vertical incision along the anterior border of the deltoid muscle The space between this muscle and the pectoralis major is opened up by retraction, and the coracoid process is defined at the upper border of the wound. The distal portion of the coracoid process, with the attached coracobrachialis and biceps muscles, is now chiselled off and retracted downwards, when the front of the shoulder-joint can be seen covered by the subscapularis tendon. This tendon is then divided, and the loose capsule of the joint opened in order to examine and define the separation between the glenoid cavity and the fibrous rim. These two are now joined by deep sutures, which pass through the ligament and through the bony margin of the glenoid cavity. The various layers are then sutured, and the movements are restored by voluntary exercises after a period of rest. The results of the operation are excellent.

Many other operative procedures have been extensively used, and of these the following are frequently employed.

Sling of Henderson. The object of this operation is the prevention of the displacement downwards of the head of the humerus, a movement which must occur before dislocation is possible. Through a vertical incision over the outer border of the acromion and head of the humerus, the deltoid muscle is split above the level of the circumflex nerve. After clearing the acromion process and the great tuberosity of the humerus, a hole is bored in the latter, through which a loop of fascia lata, or kangaroo tendon, or a slip of the tendo achillis is threaded, and then passed through a hole bored in the neighbouring portion of the acromion process. The loop of suture material is then pulled tightly and sutured

together whilst the arm is held in slight abduction. After suturing the split muscle and skin the arm is maintained in the same position for 2–3 weeks, after which the normal range is rapidly restored by voluntary movements of the joint.

Clairmont's Operation. The object of this operation is the provision of an active muscle sling under the head of the humerus, acting as an elevator of the humerus when the arm is abducted. Two skin incisions are necessary, the anterior one 5 inches in length extends downwards from the coracoid process, parallel to the anterior border of the deltoid. The muscle fibres under the incision are then split, and the quadrilateral space defined. This is slightly enlarged by dividing the upper third of the tendon of the teres major muscle; the posterior incision is then made 6 inches in length parallel to the posterior border of the deltoid muscle. The posterior quarter of the deltoid muscle is separated, together with its tendon of attachment, the separation of the muscle above ceasing below the level of the circumflex nerve. Forceps are now placed from the front through the enlarged quadrilateral space, and the separated portion of the deltoid muscle is drawn through the space and sutured in front to the split fibres of the deltoid in the anterior incision. It is essential that the nerve supply to the separated portion of the muscle be carefully preserved from injury so that the muscle fibres do not degenerate. Unless the nerve supply is retained the transferred muscle is rapidly converted into inactive scar tissue

Nicola's Operation. The aim of this operation is the retention of the head of the humerus in the glenoid cavity by using the tendon of the long head of the biceps muscle as a ligament. Through an anterior incision this tendon is defined and divided between sutures one inch below the anterior humeral ligament. A hole is now bored in the humerus from the anterior edge of the upper articular surface emerging in the bicipital groove 1½ inches below this point. The upper portion of the divided tendon is threaded through this groove, its lower end projecting from the second opening below which the two divided ends of the tendon are sutured together. The upper portion of the tendon becomes firmly adherent in the bony groove, the transarticular portion acting as a suspensory ligament.

Coracoid Osteotomy. This procedure has as its object the provision of a permanent bony block on the anterior aspect of the shoulder-joint, acting as a buttress to the joint and preventing the forward displacement of the head of the humerus

The technique is simple. Through an anterior incision in the delto-pectoral groove, the coracoid process is defined and brought downwards and inwards to the front of the joint by four vertical incisions which extend through the bone from the tip backwards and downwards. If the combined tendon of the coraco-brachialis and biceps is left attached

no complete separation of the fragments need be feared, and healing of the split coracoid results in a new elongated process which projects downwards and inwards. The movements of the shoulder are not restricted and the results of the operation are very satisfactory.

DISLOCATION OF THE ACROMIO-CLAVICULAR JOINT

Dislocation of the outer end of the clavicle may occur in a downward or upward direction as a result of severe injury, such as a fall on the tip of the shoulder. Although a downward dislocation may be seen occasionally, as a rule the outer end of the clavicle is displaced upwards with tearing of the acromio-clavicular, conoid and trapezoid ligaments. Replacement of the displaced clavicle is simple, but its permanent retention in its normal position in relation to the acromion process is usually difficult. The dislocation may be partial, or complete, the ligaments in some instances being stretched, permitting a subluxation of the joint, while separation of the articular surfaces follows complete rupture.

The disability caused by the dislocation is at first severe, the patient complains of weakness in the arm and pain at the site of the dislocation. If left unreduced, the discomfort and pain diminish in severity, and, although the deformity persists, the patient usually suffers comparatively little permanent disability.

Treatment

If treatment is instituted directly after the accident a good result is to be expected. Primary treatment consists in retaining the bones in their normal relationship, and this can be successfully accomplished by means of a tight bandage or strapping passing over the tip of the shoulder and under the olecranon, the arm being held in adduction with the elbow at right angles (Fig. 31). By this means the reduction is maintained for at least 4 weeks to allow union of the torn ligaments, and, as a rule, after this treatment redisplacement does not occur.

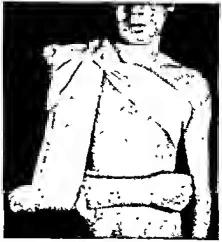


Fig. 31.—Fixation of a displaced Acromio-clavicular Joint; collar and cuff omitted for clearness.

When the deformity is old the disability is slight, but the appearance of the displaced outer end of the clavicle may cause the patient to seek relief by operation.

Various types of operations have been suggested, from arthrodesis of the acromio-clavicular joint—which, if successful, leads to diminution of abduction—to a ligamentous fixation of the clavicle to the coracoid process. Unfortunately the new ligament tends to stretch and permits redisplacement. On the whole, it is more satisfactory to treat the old dislocation by exercises, massage and free use, which tend to lessen the patient's disability and improve the usefulness of the limb.

CHAPTER VI

TUBERCULOUS AFFECTIONS OF BONES AND JOINTS

TUBERCULOUS ARTHRITIS

The primary site of infection of a joint by the tubercle bacillus may occur either in bone or in any of the soft tissues. The invading organisms may be either of the human or of the bovine type, the statistics published showing a considerable variation in the proportions of the two types occurring in different parts of the country. While these figures are of considerable interest to the research worker and the social student as indicating the probable route of infection, they are of little importance to the practising surgeon, as the clinical phenomena produced by the two types of organism are identical, and clinical examination of the patient can never demonstrate the particular type of organism which has caused the disease.

Although the deposit of bacilli may occur in any of the joint tissues, the primary infection is found most commonly in the bone itself, and less frequently in the synovial membrane. The deposit of tubercle bacilli in such a deep-seated structure as a joint is possible only if there is already present in the body a focus of bacilli which may be disseminated. This primary infection is present most commonly in the lymphatic glands, either bronchial or abdominal, from which infection may be carried by the blood or lymph streams to any area in which there is a temporarily lowered vitality. The importance of this local lowering of resistance cannot be exaggerated; when the joint tissues are healthy their resistance is such that growth of bacteria is prevented. The most frequent cause of such local devitalization is injury resulting in a hæmatoma, which forms a suitable medium for the growth of the invading bacteria. It is impossible to prove that trauma is the invariable predisposing cause of tuberculous arthritis, but clinical facts suggest a close association between these two conditions. Thus the disease is found more often in boys than in girls; it occurs more commonly in the joints of the lower limb and spine, which are those most liable to injury. The type of injury sustained by the joint is also of importance; severe injuries, such as rupture of ligaments or fractures into the joint, are never followed by tuberculous deposits, while comparatively mild injuries, such as strains, would appear to be the potent predisposing factors.

Even the most careful histories are of little value in determining the effect of previous trauma on the development of tuberculous arthritis, because every parent can remember injuries which the child suffered

at various times, which have probably had no bearing on the occurrence of arthritis, but the association between trauma and the subsequent development of tuberculous arthritis would appear to be proved.

Age and Sex. In 48 per cent of all cases the onset of tuberculous arthritis occurs between the ages of 3 and 5 years, and in 75 per cent the first sign of the disease is discovered before the age of 14 years. These figures leave no doubt as to the truth of the statement that tuberculous arthritis is essentially a disease of childhood, of the years during which the joints are liable to numerous strains and the bones bend rather than break. It is also during these years that infection by tubercle bacilli is specially liable to occur, either from relatives suffering from tuberculosis or through the medium of infected milk.

The disease occurs in equal numbers in the two sexes up to the age of 6 years, but between 6 and 13 years the proportion is 5 boys to 3 girls, a variation which can easily be accounted for by the boys' greater liability to injury.

Prognosis. In a child suffering from tuberculous arthritis the outlook as regards life is on the whole favourable. Under suitable conditions and with adequate treatment the disease can be arrested. Complete restoration of the affected joint to its normal condition does occasionally occur, but, as a rule, the disease results in destruction of at least the articular cartilage covering the ends of the bones and a consequent fibrous ankylosis

Bony ankylosis usually follows on tuberculous arthritis only when the original infection has been complicated by secondary infection, and it has been generally considered that without such mixed infection union by bone is never seen. In rare instances the occurrence of true bony ankylosis can be demonstrated following an apparently uncomplicated tuberculous arthritis, but these exceptions to the general rule are seen only in certain well-recognized areas, such as the lumbar spine. Occasionally in children, and more frequently in adults, the signs of tuberculous infection become apparent in other areas during the course of treatment of the primary disease. The presence of these multiple infections alters the prognosis, and with their occurrence the outlook for recovery is much less hopeful, death occurring in 5–7 per cent of such patients during the course of treatment for the original disease. The cause of death in such cases is found to be tuberculous infection of the meninges, of the lungs, or, when mixed infection is present, amyloid degeneration in the kidneys, liver, intestines and spleen.

Whilst the disease is essentially one of childhood it occurs comparatively frequently in the adult, either as an entirely new infection, or as a lighting up of a previous trouble from which the patient seemed to have recovered. In its clinical appearance the disease in the adult closely resembles that in the child, but in the response to treatment

and in regard to the prognosis the disease is much less favourable as the age of the patient increases.

When a child suffering from tuberculous arthritis is fixed in recumbency for a long period the result is usually an increase in weight and an improvement in general health with cessation or cure of the disease, but when an adult, similarly affected, is subjected to the same line of treatment, the progress is by no means so satisfactory. Further spread of the infection, loss of appetite and weight are commonly experienced, and more radical methods, such as excision of the disease, or amputation of the affected tissue—when this is possible—may be necessary in order to save the patient's life.

Symptoms and Signs

Although certain signs and symptoms occur only with infection of a particular joint, many of the signs are constant and appear in every instance of tuberculous arthritis wherever it occurs. These constant signs and symptoms may be described under the following headings:

Rigidity. Diminution of the normal range of movement is the first and most constant sign in every case of tuberculous arthritis. This loss of movement may be slight at first, but can always be appreciated when the joint movements are compared with the normal. Limitation of movement is not confined to those joints infected by the tubercle bacilli, but occurs in every type of arthritis, and if such limitation is absent, even in one direction, then the diagnosis of arthritis cannot be made.

If the tuberculous infection is confined to the synovial membrane, the limitation of movement is due to the presence of the thickened synovial membrane and the large effusion in the joint, which mechanically limits its range of action. Later, as the disease progresses and the articular surfaces are invaded, the movements of the roughened surfaces are prevented by reflex muscle spasm. This protective spasm is induced by movement of the roughened bony surfaces; at first, before the formation of fibrous bands, it constitutes the joint's sole protection against movement, but as the fibrous bands form and increase in strength the possibility of movement becomes less and the spasm is not so apparent or so easily induced. The amount of spasm may, therefore, be taken as an index of the stability of the joint. The greater the spasm the less the stability, and vice versa, so that with a complete bony ankylosis protective spasm is absent, and with a short, firm, fibrous ankylosis it only appears when the joint is subjected to excessive strain.

Swelling. Swelling and distension of the affected joint become apparent at an early stage of the disease. These signs can be appreciated easily in a superficial joint, such as the knee, where the swelling appears

early, at first on both sides and above the patella in the suprapatellar pouch, and later at the level of the joint itself. At first, before the synovial surface has been invaded, swelling of the joint may be due to simple irritative synovitis, caused by the close presence of a tuberculous focus. Later, the synovial and perisynovial tissues become infected, and the synovial contents are altered to a thick, gelatinous mass which blurs the outlines of the joint, both to palpation and to radiographic examination. As the disease progresses the thick fluid in the joint is gradually absorbed and the measurements of the joint may even approximate to normal, but the synovial and perisynovial thickening remain so that the bony outlines still appear more or less obscured.

On palpation the enlarged tuberculous joint has a peculiar spongy feeling, which can easily be recognized, and which constitutes its characteristic sign; although varying to some extent according to the amount of fluid present in the joint, the tissue thickening, when once appreciated, can always be recognized. The examining fingers sink in for a short distance, but the underlying bone outlines are masked by the thickened soft tissues.

Pain. Although occasionally tuberculous arthritis of the knee joint may pass through its whole course of destruction and healing without causing any pain to the patient, yet in the majority of cases pain is a prominent symptom and appears as soon as there is definite involvement of the articular ends of the affected bone. If the synovial membrane alone is involved, there is usually considerable swelling which stretches the joint and may give rise to a feeling of tension and discomfort, but the typical pain of a tuberculous arthritis follows on the involvement of the articular surfaces and is due to movement of the roughened bone ends. This movement is, to a large extent, prevented by the protective contraction of the muscles controlling the joint, but, if the limb is jerked so that the muscles cannot prevent movement, or if the muscle spasm is relaxed, as in falling asleep, then the movement thus produced gives rise to the sudden stabbing pains, which are so characteristic and so well known under the description of "night cries"

Muscle Atrophy and Muscle Spasm. These two conditions which would seem to be mutually antagonistic are present in all the muscle groups acting on the affected joint. The atrophy appears rapidly and becomes so extreme that it cannot be explained solely on the theory of disuse atrophy. As previously explained, the muscle spasm also appears as soon as a true arthritis is present, and remains until the disease is cured, or until a firm fibrous or bony ankylosis is present and movement becomes impossible.

Deformity and Shortening. These two clinical conditions are usually present to a varying degree when the infection has involved one of the larger joints of the limbs. The true shortening of a limb is

the result of destruction of bone, especially when the growing epiphyseal plate has been lost. In addition to the shortening, the affected limb is usually deformed and may, on this account, appear even shorter unless the joint has been protected during the period of destructive changes.

Abscess Formation. A slowly forming "cold" abscess frequently complicates tuberculous arthritis. The abscess, which is characterized by the absence of heat and pain, is composed of a fibrous lining wall in which can be demonstrated numerous tubercle bacilli. The contents of the abscess cavity consist of a mass of broken-down tissue and blood cells in which a few tubercle bacilli can be found if the abscess is of recent formation. In the contents of an old-standing abscess it is difficult, or impossible, to demonstrate tubercle bacilli, although their presence can usually be proved by injection of some of its contents into a guinea-pig.

As a rule, under efficient conservative treatment, the abscess gradually absorbs and disappears, and no surgical intervention or opening of the cavity is advisable or necessary. Occasionally, however, the abscess may press on important neighbouring structures, or may threaten to burst through the skin or into a neighbouring cavity. It is advisable to aspirate such an abscess through adjacent healthy skin, or, if the contents consist of thick caseous matter, which cannot pass through the needle, a small incised wound—made under strict aseptic precautions—may prevent a tragedy, but the mere presence of a cold abscess is not of itself an indication for surgical interference.

General Signs. The presence of tuberculous arthritis is usually associated with an appreciable loss of weight. Elevation of the temperature 1–3 degrees each afternoon is commonly found during the activity of the disease. Persistence of this rise of temperature indicates activity in the lesion, and should always be considered as a definite contra-indication to the activity of the patient.

If the disease progresses the skin may assume a distinct yellow tinge, even when the tuberculous arthritis is uncomplicated by mixed infection. When other organisms have been admitted to the area of tuberculous infection—usually through the medium of an open sinus—other grave changes take place. The liver, spleen and kidneys may become the seat of amyloid changes, which are indicated by enlargement of these organs, and in the kidneys by the passing of urinary casts and occasional traces of blood. These changes occasionally occur where the infection is uncomplicated, but are found much more frequently when a pyogenic infection has been added to the original tuberculous lesion.

Radiographic Appearances. As a rule in the early stages of tuberculous arthritis no definite area of bone destruction can be demonstrated, but even at this stage widespread decalcification is present in

all the bony structure of the joint. This decalcification increases rapidly and one or more areas of bone destruction usually appear beyond the epiphyseal line, or on the articular surfaces themselves. The clear outlines of the bones are lost and a peculiar condition of "fuzziness" is seen, especially on the area of greatest bone destruction.

Soon the joint space becomes narrowed until eventually it almost disappears, and the smooth articular surfaces are destroyed, leaving irregular eaten-out areas. The appearance of these areas of necrosis is peculiarly characteristic, because tuberculous arthritis is essentially destructive in character with little or no attempt at new bone formation. Some indication of improvement can be seen later when the decalcified bone becomes recalcified and the "fuzziness" disappears and is replaced by the sharply defined, although irregular, outlines of sclerosed bone.

Diagnosis

In making the diagnosis of tuberculous arthritis the surgeon must place considerable weight on the clinical signs. If all or most of these are positive, there is a strong suggestion that the arthritis is the result of infection by the tubercle bacillus. Some help in confirming the diagnosis may be obtained by the use of the skin reactions of Von Pirquet and Mantoux. The reactions are at best only suggestive of the diagnosis; thus, a positive reaction in a child over the age of 3 does not of itself indicate the nature of the arthritis, previous infection by the tubercle bacillus being usually present in some other part of the body, nevertheless a negative reaction is of considerable diagnostic value.

The only method by which the diagnosis can be made with certainty is the discovery of tubercle bacilli, either in the contents of the joint or in the joint structures. Absence of the bacilli from the aspirated material does not prove that the infection is not tuberculous, but the risk of an exploratory arthrotomy for diagnostic purposes is, in my opinion, seldom justifiable on account of the grave danger of the persistence of a sinus.

Treatment

As tuberculous arthritis is a sign of generalized infection, treatment must not be confined to the joint itself, but should aim at the elimination of the whole disease. The measures employed can be divided into two sections, general and local treatment, which are to a large extent interdependent.

General Treatment. General treatment depends largely on the provision of fresh air, good, plain, easily digested food, and sunlight when available. This line of treatment is carried out most effectively

in an open-air ward or balcony. It must be continued without interruption summer and winter, a little extra precaution being needed to protect the patient from cold in winter or heat in summer. This line of treatment usually results in a rapid increase of the patient's weight, an improvement in the appetite and a general increase of metabolism. Sunlight, whether of the natural or artificial variety, is useful when used in moderation, but more harm than good will be done if careful supervision is not used, and frequent checks made as to the effect of sunlight on the patient's general health. The object of treatment by sunlight is improvement in the general metabolism of the body, as evidenced by the increased excretory activity of the skin, improvement in the respiratory action of the chest, and increase in the appetite. Usually, the first and most obvious effect of sunlight consists in pigmentation of the area of skin which has been exposed to its action. This pigmentation is of considerable clinical importance and may be taken as a guide to the effect of sunlight on the patient. Where pigmentation rapidly follows exposure to sunlight the patient's general condition improves, weight increases and temperature diminishes, but where no pigmentation occurs after prolonged exposure no such beneficial effects follow the application, the temperature rises, the appetite is poor and the patient complains of a feeling of sickness.

Treatment by sunlight, either natural or artificial, may be carried out generally or locally. In the first method it is used as a general body tonic, its effect on any particular lesion being indirect through an improvement in the body metabolism. In the second, the application is confined chiefly to the affected area, although there may at the same time be some exposure of the rest of the body. In the treatment of tuberculous arthritis artificial sunlight is of value only because of its effect as a general stimulant, and its use should be limited to its action as a general tonic. Treatment of the disease by local application of artificial sunlight is definitely dangerous as its use is frequently followed by an increase in the extent of the disease, especially when this is complicated by the presence of a sinus. Exposure to sunlight, of either type, should at first be limited to a period of 5 minutes per day; this period may be gradually increased up to a maximum of 5 or 6 hours in the case of natural sunlight, careful supervision always being given to its effect, any signs of over-exposure or ill effects being dealt with at once by its temporary cessation.

Local Treatment. As tuberculous infection of the joint is always accompanied by inflammatory changes in all the neighbouring tissues, local treatment must consist primarily in rest of the inflamed area until the activity has disappeared and the joint has become ankylosed, or movement has been restored.

It is evident that the means adopted to promote rest of the joint

affected must vary with the different regions of the body, but certain principles must underlie the methods which are employed.

1. The apparatus used must be sufficiently strong to maintain complete rest of the affected joint.

2. Voluntary muscular movements which might act even indirectly on the affected limb must be controlled.

3. If possible the affected area should be left uncovered and open to the sunlight and air.

4. Fixation must be continued until all inflammation has disappeared.

5. When definite signs of resolution of the disease appear function of the joint may be permitted.

6. If the joint has become soundly ankylosed use may be permitted without protection.

7. By prolonged fixation an unsound fusion is frequently converted into a sound ankylosis.

8. If, in spite of prolonged fixation, the ankylosis remains unsound and the position of the joint alters with use, a sound fusion should, where possible, be obtained by operation.

TUBERCULOUS INFECTION OF BONE

Bony tissues show several different types of reaction to infection by the tubercle bacilli Just as in the case of tuberculous arthritis, the condition is always secondary to some primary focus, from which the bacilli are carried by the lymph or blood-stream. The age period during which tuberculous infection of bone occurs is roughly the same as in the case of tuberculous arthritis, and in both a previous trauma is probably an important factor in the onset of the disease.

TUBERCULOUS PERIOSTITIS

Inflammation of the surface of the bone may be caused by the deposit of tubercle bacilli, either on the outer surface of the cortex or on the deep aspect of the periosteum In either case the surface of the bone becomes affected, the disease spreads rapidly along the bone, and to some extent into its substance along the course of the perforating vessels. With the spread of the disease its centre softens, forming a pulpy granulomatous mass, caseation and abscess formation rapidly appearing. Over this softened area the skin becomes stretched and one or more sinuses appear, bringing with them the possibility of mixed infection and amyloid changes. The effect of tuberculous periostitis on the underlying bone depends largely on the structure of the affected bone, when occurring in connection with a dense bone, such as the

tibia, only slight superficial necrosis may result, but with soft cancellous bones, such as the vertebral bodies, widespread infection and destruction appear rapidly.

Treatment

In its early stages, when the infection is confined to the periosteum, complete rest of the affected part, with open air, good food and sunlight, often result in cure of the disease, the healed bone being considerably thicker and denser than normal.

When an abscess has formed and is threatening to burst through the skin, conservative treatment fails and operation is indicated if the disease is situated at an area where operation is possible.

Operation. After opening up the infected area widely the abscess is gently swabbed out and the area of disease dealt with by the removal of any necrotic pieces of bone. The operation wound is then completely sutured, and conservative treatment is continued as before until signs of bone sclerosis and healing become evident.

Subperiosteal resection of the affected bone may be used with advantage, the whole of the infected tissue being removed, and the possibility of non-union following the wide removal of bony tissue can be considered as a justifiable risk.

TRUE TUBERCULOUS OSTEITIS

is found in one of two forms:

(*a*) Localized or encysted.
(*b*) Diffuse osteitis.

(*a*) Localized Tuberculous Osteitis

This—the more chronic type—occurs as a rule in the metaphysis of one of the long bones. The disease appears usually as a cavity in the bone in which the cancellous tissue has disappeared. Round the area of infection appears an area of thickening or sclerosis, which is often difficult to differentiate from the dense sclerosis which surrounds a local area of septic infection (Fig. 32).

The history of the affection may extend over several years with a complaint of chronic aching, but without severe pain at any stage. The affected bone is somewhat enlarged and the neighbouring joint may be restricted in movement owing to this enlargement, and to the presence of a simple irritative synovitis.

Differential Diagnosis. The only difficulty met with in diagnosis is the demonstration of the type of organism which is responsible for the bone necrosis. Usually the amount of sclerosis round a tuberculous

infection is less than that round an area of bone infected by pyogenic organisms, but it is frequently impossible to make a certain diagnosis without opening of the cavity and examination of the contents. With *tuberculous osteitis* the contents of the cavity are of a caseous nature and the cavity is lined by thickened pulpy granulation tissue. The diagnosis should always be confirmed by guinea-pig inoculation.

FIG 32.—Tuberculous Osteitis of Neck of Femur, not involving Hip-joint

Treatment. In certain areas, particularly the metaphyseal ends of the tibia, fibula, radius, ulna or humerus, these chronic encysted bone abscesses can be cleared out by operation with little fear of infection of the neighbouring joint When the cavity is situated near the hip-joint, either in the neck of the femur or at the edge of the acetabulum, even the most careful opening and clearing out is usually followed by infection of the joint, and a more favourable result can be expected from prolonged rest of the affected area.

(*b*) Diffuse Tuberculous Osteitis

This condition is seen most typically in the metacarpals, metatarsals and phalanges. The medulla of the bone is transformed into pulpy

granulation tissue containing tubercles, and the cancellous tissue is destroyed. Sequestra are often seen; these are soft, friable and yellowish-white in appearance (Fig. 33). If a sinus has formed and mixed infection results, minute spicules of dead bone usually come away in the discharge.

With this type of infection the bone becomes enlarged, the medullary portion being eaten away, whilst new bone is thrown down on the surface from the periosteum. Frequently the disease does not extend through the whole length of the bone and, as a result, the infected area becomes shut off from the healthy bone by an area of osteosclerosis.

FIG. 33.—Tuberculous Dactylitis of both hands.

Differential Diagnosis. The chief difficulty met with here is the diagnosis of the condition from syphilitic dactylitis, in which there is usually more new bone formation, as shown in the radiograph—sequestra are frequently seen in tuberculous infection but not in syphilitic dactylitis —whilst help is given by an examination of the Wassermann reaction in the blood or cerebro-spinal fluid.

Treatment. Prolonged fixation of the affected area results, as a rule, in improvement or cure of the condition. If an abscess develops and is threatening to burst through the skin, widespread opening and clearing out of the infected tissues, as already described, is usually followed by healing, with occasionally some deformity of the affected digit.

CHAPTER VII

TUBERCULOSIS OF THE HIP-JOINT

The primary infection in tuberculous arthritis of the hip-joint occurs, as a rule, in bone, either in the head or neck of the femur or in the upper border of the acetabulum. That primary synovial infection can and does occur seems to be true, as so often the clinical signs are present long before any bone focus can be demonstrated. In children the primary focus is present more frequently in the upper border of the acetabulum than in the femur, but in older children and in the adult the cervical area is more often involved (Fig 31).

Fig. 31 —Tuberculous focus in Acetabulum

Radiographic Appearances. Frequently after a clinical diagnosis of tuberculous arthritis in a child the radiograph demonstrates a diffuse decalcification of the upper end of the femur and of the acetabulum. This appearance may remain unaltered for several months, but eventually destruction of the articular surfaces proceeds rapidly, the joint space is lost and the two roughened bony surfaces are pressed together by muscular contraction, combined in the untreated cases with the strain of weight-bearing. Unless the progress of the disease is controlled more

FIG. 35.—Tuberculous focus in Neck of Femur involving Hip-joint.

and more bone becomes infected, softened and inflamed. Destruction and bone loss are present, particularly at the upper border of the acetabulum, which yields to pressure, the head of the femur travelling upwards in the enlarged cavity on the side of the pelvis (Fig. 35). This alteration of position, the so-called "travelling acetabulum," always occurs in an upward direction and is a direct result of pressure between the two inflamed bony surfaces. Not infrequently the disease may spread into the pelvis after perforation of the wall of the acetabulum. Spread of infection in this direction usually leads to generalized infiltration of

the neighbouring tissues with involvement of the inner side of the pelvic brim.

Symptoms and Signs

In children the onset of the disease is, as a rule, peculiarly insidious and hard to detect. An afternoon temperature is present in most patients, but generally the first sign is a limp, which is worse when the child is tired but almost disappears after rest. Soon the limp becomes constant and is accompanied by complaints of aching or tiredness, but a history of severe pain in the early stages is the exception. Pain, when present, is not usually complained of in the region of the hip, but is referred to the front of the thigh or the inner side of the knee, over the distribution of the anterior crural and obturator nerves, each of which gives a branch of supply to the hip-joint. As soon as efficient treatment has commenced this pain usually disappears, and its persistence in spite of efficient treatment is very suggestive of abscess formation.

On examination in the early stage there is usually some tenderness on pressure over the front of the joint, with limitation of movement in every direction as compared with the normal range. In the earliest stage, when the joint is full of fluid but before there is definite articular erosion, the leg is held in a position of slight abduction with some external rotation of the thigh, the position in which the cavity of the hip-joint can be distended to its greatest extent without exerting painful tension on the joint structures. This stage of apparent lengthening does not, as a rule, last long and has usually disappeared before the patient comes under the surgeon's care. As soon as erosion of the cartilage develops muscle spasm comes into action; all the muscles acting on the joint take part, the adductor group—on account of its great strength—bringing the leg into deformity, the stage of apparent shortening. With further destruction of the articular surfaces and of the underlying bone the stage of true shortening appears, in which the real loss of length of the limb—caused by absorption of bone—is associated with adduction, flexion and internal rotation of the hip.

This problem of true and apparent shortening can be easily understood from a study of the diagram (Fig 36) If a hip-joint is ankylosed, without bony destruction, in the neutral position the two legs will appear to be, and will really be, equal in length, but if a hip-joint is ankylosed in abduction without flexion, the affected leg appears longer than the normal because of the tilting upwards of the pelvis on the normal side Similarly, if the joint is ankylosed in adduction the leg on the affected side appears shorter than normal because of the abduction of the normal hip and the lowering of the pelvis on that side.

Periarticular infiltration and thickening can be appreciated over the front of the joint soon after the onset of the disease, but although

abscess formation is of common occurrence at the later stages, very rarely can such collections be demonstrated as an early complication. Although the abscess may approach the surface and be palpable on any aspect of the joint, its usual point of appearance is the anterior aspect, slightly to the outer side of the joint in front of the great trochanter.

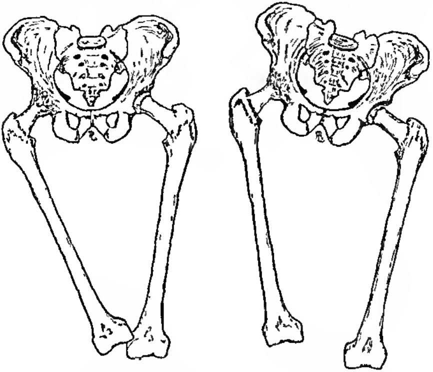


FIG. 36.—Showing Apparent Shortening due to Adduction Deformity in Ankylosis of the Hip-joint

Occasionally, when the disease has extended into the pelvis through the floor of the acetabulum, the abscess may point above Poupart's ligament, or be felt on rectal examination. Muscular wasting of all the groups acting on the affected joint appears at an early stage and remains as a permanent feature.

Examination of the Hip. This should be carried out while the patient lies uncovered on the examination couch; all the movements of the affected joint must be compared with the normal. As many of these patients are young children the examination should be conducted slowly, and every effort should be made to gain the child's confidence. The limb should not be grasped roughly in the hand, but should be held lightly with the fingers. The range of abduction, adduc-

tion, flexion, extension and rotation should each be recorded, and if any one of these movements can be carried out freely to its full extent the possibility of arthritis may be excluded. If the examination is conducted without first removing the clothes, incorrect conclusions are almost certain to be drawn as the apparent range of movement in any particular direction may be greatly increased by rotation of the pelvis.

Thomas's Test. As a rule, the first sign of loss of movement in the affected hip-joint is an inability to hyperextend the thigh without flexing the lumbar spine, on this rests the Thomas hip-flexion test. In carrying out this test the normal lumbar lordosis is obliterated by flexing the sound hip so that the front of the thigh lies close to the abdominal wall. This flexion must be sufficient only to obliterate the lordosis, and must not be so *extreme as to result in tilting the pelvis from the couch (Fig. 37)*

FIG. 37.—Thomas's Hip flexion Test

Whilst the spine and pelvis are thus kept flat on the examining couch, the patient is encouraged to put the other thigh and leg on the table. If this is possible, then flexion deformity is not present, but if the limb cannot be placed flat on the couch, then the amount of flexion deformity present in the affected hip can be judged as being equal to the angle between the couch and the thigh in its position of fullest possible extension.

DIFFERENTIAL DIAGNOSIS

Among the many conditions with which tuberculous arthritis of the hip-joint may be confused are the following:

1. Transient Synovitis, a condition characterized by limitation of movements, slight tenderness and very occasionally some suggestion in the radiographs of decalcification of bone, which cannot be differentiated from the appearance of an early case of tuberculous arthritis of the joint. The cause of the synovitis is probably a mild septic infection, but its appearance and clinical signs are so like those of early tuberculous arthritis of the joint that the differential diagnosis is usually based on

the response to treatment. When treated by rest and fixation the rigidity rapidly disappears, whilst in the case of tuberculous arthritis the response is extremely slow, and evidence of bone destruction generally appears.

2. Legg's, Calvé's or Perthe's Disease, an affection of the hip-joint which was previously mistaken for tuberculous disease, and characterized by limitation of abduction, adduction and rotation of the joint, whilst flexion and extension are retained to almost their normal range. The radiographs show flattening and fragmentation of the head of the femur (Fig. 76) with, as a rule, the appearance of indefinite cyst-like spaces in the neck of the femur and occasionally in the edge of the acetabulum.

3. Septic Arthritis or Epiphysitis of Children, a condition of acute infection occurring usually in the first year of life, and characterized by destruction of the head and part of the neck of the femur, with a history of abscess formation, leaving a joint unusually mobile in all directions.

This disease probably arises as an osteomyelitis of the intra-articular portion of the femur. Although no definite bony or cartilaginous mass is extruded from the sinus, the infection results almost invariably in

FIG. 38.—Suppurative Arthritis of Hip-joint occurring in Infancy.

complete loss of the head and the upper part of the neck of the femur without destruction of the acetabulum (Fig. 38). As a result the joint is abnormally mobile, unstable and painless, and the affected leg is considerably shorter than normal on account of the loss of growth from destruction of the upper epiphysis of the femur, and the displacement upwards of the great trochanter on the outer side of the ilium.

4. Disease of Spine and Sacro-iliac Joint, Appendicitis and Perineal Abscess. Any of these conditions may give rise to flexion of the hip-joint, but disease of the joint may be excluded by the presence of free rotary movements.

5. Coxa Vara and Congenital Dislocation of the Hip are easily differentiated by the freedom of movements and the radiographic appearances.

6. Osteoarthritis of the Hip usually occurs in a different decade of life, and, although movements are limited, the radiographic appearances indicate heaping up of bone round the acetabulum in contrast to the destruction, without new bone formation, which is characteristic of tuberculous arthritis.

7. Extra-articular Tuberculous Osteitis. Bone infection, situated close to the joint, may give rise to signs and symptoms closely simulating those of tuberculous arthritis. The most common sites of such deposits are the neck of the femur, or the upper border of the acetabulum, either of which leads to a limitation of movement in the joint in one or more directions The differential diagnosis rests largely on the presence of a full range of movement in at least one direction, and also on the radiographic appearances, which from an early date show an ill-defined cut-out area of bone necrosis, which is present close to, but not in, the joint cavity (Fig. 32).

Prognosis

In spite of adequate treatment a certain small percentage of patients have such a low resistance to the tubercle bacillus that a fatal result is inevitable from even an uncomplicated affection of the hip-joint, but as the provision of efficient general and local treatment has improved this percentage has rapidly diminished. Every true tuberculous arthritis ends in the formation of a fibrous or bony band of union between the injured articular surfaces. Uncomplicated tuberculous infection of the joint is almost invariably followed by fibrous union, whilst the bony type is the result of an infection which has become mixed, usually through the medium of a sinus. The greatest safeguard against recurrence of disease, or the subsequent appearance of deformity, depends on the presence of bony fusion, yet a strong fibrous union functions almost equally well and prevents deformity later.

Treatment

General treatment, with the object of improving the patient's resistance to the general infection, must be employed in conjunction with the type of local treatment considered most suitable. Continuous treatment in an open-air ward or balcony, cheerful surroundings, and an adequate supply of light, easily digested food are all essential in improving the patient's metabolism. It is not necessary for every child suffering from tuberculous arthritis to be admitted to hospital if suitable conditions can be arranged at home, as a very nervous child progresses more satisfactorily amid normal surroundings if the treatment is equally efficient.

Local Treatment. Before considering details of local treatment the surgeon must realize that the reaction to the prolonged recumbency which is necessary for the complete fixation of the affected joint varies with the age of the patient. In the child suffering from tuberculous arthritis recumbency can be continued with safety for many months or even years without risk to the general health, nud with excellent prospects of cure of the disease.

In the adult a similar period of immobilization is not borne so well; spread of the disease, rise of temperature, the appearance of kidney casts or blood in the urine are all indications that indefinite recumbency is inadvisable and that, where possible, more radical surgical procedures should be undertaken. The disease may, therefore, be said to take two distinct forms—the mild type occurring in children, which is best treated on purely conservative lines, and the more virulent type of the disease seen in the adult, which may require radical interference.

The object of all treatment is the prevention of movement and of excessive pressure between the roughened articular surfaces of the femur and acetabulum. This pressure may be the result of protective muscle spasm alone, but is greatly increased when the strain of weight-bearing is superadded.

Many attempts have been made to treat tuberculous arthritis of the hip by strong continuous traction applied to the limb with the object of separating the two inflamed bony surfaces from each other, thus preventing any possible pressure between the roughened bones. This line of treatment can never be successful as the amount of traction required to produce separation between the articular surfaces is so great as to be unbearable. If an attempt is made to use this method the patient complains, the pressure is lessened and its effect is naturally lost.

The aim of any form of treatment must primarily be the elimination of spasm from the protecting muscles, and the prevention of the excessive intra-articular pressure which leads to further destruction. These objects can be attained by fixation of the joint and prevention of weight-bearing on the affected limb.

As soon as the diagnosis of tuberculous arthritis is made, treatment should be begun immediately. The acute stage of the disease is usually characterized by an afternoon rise of temperature, pain and possibly night cries and a poor general condition. In all cases presenting this syndrome treatment by fixation in recumbency is essential. The presence of a raised temperature is an indication of activity of the disease and is a distinct contra-indication to the activity of the patient.

Many types of splints, as well as plaster of Paris, are used for fixation of the joint, and if the immobilization is adequate the object has been secured. Of the splints in general use the Jones abduction splint (Fig. 7) is the most easily handled, being so designed that the affected joint can be retained at any desired angle, even when the patient is moved from room to room Fixation is obtained by using strapping extensions applied to the leg and thigh, and fixed to the extension bars at the end of the frame. Counter-pressure is provided by means of a groin strap which takes its purchase from the opposite ischial tuberosity and is attached to a curved bar fixed to the frame on that side just above the crest of the ilium An additional fixation of the sound leg is also obtained by strapping it to the bar at the end of the splint on the same side. The extensions are pulled tight and tied to the end of the splint, and the legs bandaged firmly to the bars at the side and back, a large pad being placed behind each knee-joint to prevent hyperextension until treatment on the frame is completed.

During the first few days the extensions become loose as the muscle spasm disappears and the leg settles down into position on the splint. Retightening of the strapping, at first daily, and then every 3 or 4 days, maintains the fixation, which should be continued until signs of recovery are evident (Figs. 39*a*, 39*b* and 39*c*). These favourable signs are

1. Cessation of afternoon rise of temperature.
2. Cessation of pain.
3. No sign of abscess formation or great thickening round the joint
4. Improvement in general health.
5. Recalcification of the area of disease, as shown in the series of radiographs.

The presence of deformity must modify the type of treatment which is employed; if slight and solely the result of muscle spasm, use of the frame and continued fixation lead to a rapid correction, but in the presence of a fibrous ankylosis such attempts at correction will probably be unsuccessful Under these circumstances correction of the deformity under anæsthesia, followed immediately by fixation on the frame, is often successful. This method of correction, although apparently open to many serious objections, has never in my experience led to untoward results or to spread of tuberculous infection.

1847

io. 39*a*.—Tuberculous disease of Hip joint
Condition acute

**Fig. 39*b*.—Tuberculous disease of Hip-joint
Condition quiescent**

Fig. 39*c*.—Tuberculous disease of Hip-joint.
Sound fibrous ankylosis has been obtained.

During the whole of the recumbent treatment the patient must not be removed from the frame, which is so constructed that nursing details and the skin of the back and groin can be attended to without in any way interfering with the efficacy of fixation. The skin over any point of pressure is kept healthy and unbroken by gentle rubbing with methylated spirit, or washing with soda-free soap, which is followed after careful drying by the application of a thin coating of dusting powder. In this way the skin is kept dry and hard and sores are prevented.

Abscesses, which are relatively uncommon in a hip so exposed to open air and sunlight, are dealt with as described previously, aspiration or incision being used only in those cases where the abscess threatens to burst through the skin or gives trouble on account of its size and proximity to important structures.

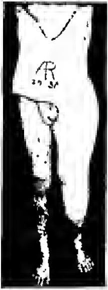


Fig. 40 —Plaster Spica.

When the so-called convalescent stage has arrived and the signs of recovery appear, ambulatory treatment should be employed, occasionally, especially in the adult, it may be necessary to make this change before recalcification is well advanced, protection against weight-bearing still being necessary. This can be accomplished very effectively by the application of the Thomas single hip splint, or a plaster spica, combined with the use of a pair of crutches and a patten under the other boot. Later, when recalcification is apparent and the other signs are favourable, weight-bearing may be permitted, even though protection is still necessary, in order to prevent alteration of the angle of fixation of the ankylosed joint Probably the most efficient form of support at this stage is the long plaster spica (Fig 40). It is important to realize that this method of fixation is not part of the treatment of tuberculous arthritis but is used simply as protection of the ankylosed joint against the probability of deformity, the result of yielding of the fibrous union. The protection must be continued so long as it is possible to elicit the protective muscle spasm round the hip by a rapid jerk of the leg

Operative Treatment. If it is obvious that a sound ankylosis cannot be obtained in spite of prolonged conservative treatment, fusion of the femur to the ilium by operation should be undertaken when conditions are suitable. The fusion should not be attempted at too early an age; although successful results of operation are occasionally seen in young children, it is advisable to restrict this form of treatment to those above the age of 12. The appearance of activity of the disease,

either from the clinical examination, or in the radiograph, should be considered as a contra-indication.

It is probable that operative fusion of the affected hip is advisable in about 90 per cent, the remainder having developed an ankylosis which, if not bony, is sound and does not yield when subjected to the strain of body weight. At operation an attempt may be made to excise all the diseased tissue as a preliminary to union between the affected bones, or the area of disease may be by-passed, the bones being joined at a distance from the diseased area.

The types of operation usually undertaken are:

1. Intra-articular arthrodesis.
2. Extra-articular arthrodesis.
3. Combined operation using both methods.
4. Ischio-femoral arthrodesis.

1. Intra-articular Arthrodesis. In this operation an attempt is made to remove all the infected tissue, whether this be synovial, peri-synovial or bony, the articular cartilage being removed from the acetabulum and from the head of the femur. It is a comparatively simple matter to remove all the diseased tissue but, if not combined with some other procedure, bony union between the femur and ilium rarely results.

The explanation of this failure of union is evident; when the head of the femur and the acetabulum are covered by a thick layer of cartilage there is a close approximation of the two surfaces, but after removal of this cartilage and any infected bone lying at a deeper level, a very small head lies loose in a very large acetabular cavity.

2. Extra-articular Arthrodesis. This method has for its object the provision of a bony bridge between the ilium and the great trochanter, the whole procedure being completed without opening the infected joint. A large flap of bone, starting at the crest, is turned down from the outer plate of the ilium, its attachment at its lower border being unbroken, while the upper end of the flap is implanted into a cavity provided in the great trochanter. If only used in patients over 10 or 12 years of age the results of this operation are excellent; shock is comparatively slight and bony union occurs in at least 85 per cent of the patients so treated.

Bony fusion between the great trochanter and ilium can also be obtained, although not with the same certainty, by the operation of Albee, in which bone grafts from the tibia are used to bridge across the space between the slotted great trochanter and the side wall of the ilium above the acetabulum.

3. Combined Arthrodesis. This method, which is a combination of the procedures just described, is undoubtedly the most mechanically

efficient of all these operative procedures, although when dealing with tuberculous arthritis of the hip, the results obtained by the extra-articular method alone are so good that it is usually inadvisable to subject the patient to the greater shock of the combined operation. In carrying out the operation the diseased area is widely exposed, and all the infected soft tissues removed. The adjacent surfaces of the femur and acetabulum are now cleared of disease and placed in apposition, a large flap of the outer plate, or the whole of the ilium at least 2 inches in breadth, is now turned down, leaving the lower portion in situ and unbroken (Figs. 41*a* and 41*b*) The iliac flap is now carefully bent into a hoop

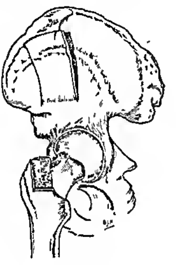


FIG 41*a*.—Arthrodesis of Hip-joint

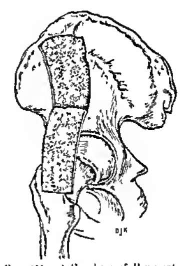


FIG 41*b*.—Arthrodesis of Hip joint showing Extra-articular Flap

so that its original upper border may be implanted into a cavity which is prepared for it in the great trochanter. The cavity on the femur is most suitably made by a straight chisel which forces out the outer layer of the great trochanter, thus leaving a wedge shaped cavity in which the iliac flap is easily retained The muscles and soft tissues are now sewn into position and a long plaster spica is applied from the lower ribs to the foot in order that there may be complete fixation of the joint The plaster fixation is usually necessary for 6 months, and should only be removed when the radiographs show sound bony union (Fig 42). Occasionally after the operation one or more small sinuses develop in the line of the skin incision, but fortunately these do not remain open for long and seldom give rise to any trouble.

When walking is permitted, the use of a plaster-of-Paris cast or leather

hip shield for 6 months is of considerable value in giving the patient confidence and protecting the joint against the strain to which it is subjected in walking.

FIG. 42.—Position of Ankylosed Hip after corrective Osteotomy

4. **Ischio-femoral Arthrodesis.** A method of fusing the shaft of the femur to the ischium has recently been described by Brittain, and seems to offer certain advantages over the other methods of extra-articular fusion. In this operation the shaft of the femur is divided obliquely, upwards and inwards, at such a level that the upper sharp end of the shaft of the femur lies about the middle of the ischium. Through the line of femoral division the osteotome continues inwards until it pierces the ischium, the cavity in this bone is then enlarged by rotation of the chisel and the upper sharp end of the femur inserted into the space provided. Union between the femur and the ischium is

(a)

(b)

stimulated by the use of a tibial bone graft which is slid along the oblique upper surface of the lower segment of the femur until it enters into the cavity in the ischium. The shock in such an operation is undoubtedly greater than that experienced with the other methods, but if union is obtained, pressure on the diseased joint is entirely eliminated and healing occurs rapidly.

Transtrochanteric Osteotomy is a simple operative measure by which the alignment of the hip-joint can be altered (Figs. 43 *a* and *b*), when this is desired following ankylosis of the joint in a bad position. As a rule, the deformity is a combination of flexion and adduction with some internal rotation and this position may follow on conservative or operative treatment provided the period of fixation has been insufficient.

Operation. Through a small incision over the great trochanter an osteotome is used to divide the bone in a line downwards and inwards towards the base of the neck. This line of division should be roughly parallel with Poupart's ligament, and should extend completely through the bone; this incision in the bone must be close to the base of the neck, as a low or subtrochanteric osteotomy leaves the upper fragment of the femur pointing forwards, with the danger of puncturing the overlying vessels and skin.

Following the osteotomy the patient is placed on an abduction frame (Fig. 7), on which complete correction of the deformity can be obtained in the course of 2–3 weeks. The use of the frame has very great advantages over plaster-of-Paris fixation, as complete correction of the deformity is impossible at the time of operation. The soft tissues round the joint are contracted and yield only to continuous pressure, which causes a slow and gradual correction.

When union of the osteotomy is sound, walking may be permitted in a plaster case, which must be retained for 4–6 months, and this method of fixation may, if necessary, be continued for another 6 months by means of a leather hip shield until there is no sign of muscle spasm and until the radiographs show solid bony union at the site of osteotomy.

TUBERCULOSIS OF THE KNEE, ANKLE AND TARSUS

KNEE-JOINT

In the knee the primary deposit of tubercle bacilli occurs more frequently in the synovial membrane than in any other of the large joints of the body. It is comparatively common to find an apparently simple chronic synovitis of the knee, proved by biopsy to be due to tuberculous infection of the synovial lining, while at the same time the underlying bone is to all appearances healthy. Occasionally this localization of the infection may persist to the termination of the disease, but, as a rule, the infection spreads and a true tuberculous arthritis develops with destruction of the articular surfaces (Fig. 44) Primary bone infection also occurs, the femur or the tibia being the usual sites, although a localized tuberculous infection of the patella does occur on rare occasions As soon as the tuberculous infection enters the joint cavity it spreads rapidly over the synovial membrane, and over the articular cartilage, on both of which it forms a layer of granulation tissue. The bone behind the articular cartilage also becomes involved, and the cartilage which, in itself, is highly resistant to the spread of the disease, becomes separated from the underlying bone and cut off from its normal blood supply in localized areas. The whole of the joint and the supra-patellar pouch become involved, synovial fibrosis leading to disappearance of the joint cavity, while the infiltration and thickening of the synovial membrane and perisynovial tissues produce an

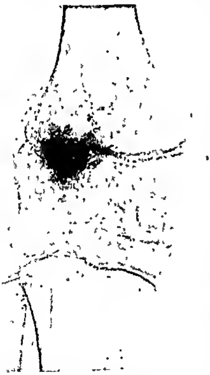


Fig. 44 —Tuberculous disease of Knee joint showing destruction of condyle of femur and internal tuberosity of tibia

apparently excessive distension of the joint. This infiltration of the tissues round the joint causes a peculiar and characteristic pulpy feeling, which can be readily appreciated, and is of considerable value in distinguishing between tuberculous and all other varieties of joint infection.

Symptoms and Signs

When the infection reaches the joint, the muscles of the thigh and leg undergo a rapid and extensive atrophy, which is so extreme that it cannot be explained as being the result of simple disuse alone. At first, the infected joint is dilated with almost clear synovial effusion, but, as the surface of the synovial membrane becomes ulcerated, the character of the contents alters, becoming semi-solid and extremely difficult to aspirate. Peri-articular infiltration of the tissues appears rapidly, and signs of abscess formation, as indicated by localized softening, may appear at any stage. Because of the intense inflammation the ligaments become softened, and unless adequate protection is given the knee becomes flexed, and the tibia slowly subluxates backwards on the femur, until eventually only the anterior margin of the upper articular surface of the tibia may be in contact with the lower end of the femur.

Pain is very rarely a prominent feature of the disease, occurring usually in spasms originated by unguarded movements of the roughened joint surfaces. As most of the growth in length of the lower limb occurs round the knee, the presence of inflammation in this area must cause considerable retardation in growth or may even lead to overgrowth. If there has been no true bone destruction but simply a condition of inflammation, extending over a long period, overgrowth of the femur or the tibia is a comparatively common sequela. If the epiphyseal plates of the tibia or the femur have been destroyed the interference of growth may lead to an obvious shortening of the limb, while deformity—such as knock-knee or bow-leg—may readily follow on a localized destruction.

Differential Diagnosis

Chronic Synovitis. This condition is differentiated with the very greatest difficulty—in both conditions there is often a history of accident. In both there is the long-continued swelling of the joint, while pain is seldom present to a noticeable degree, a feeling of discomfort being complained of more frequently than actual pain. The reaction of the affected joint to prolonged rest frequently helps in distinguishing the two conditions. With chronic synovitis the swelling usually disappears rapidly, while the thickening of a tuberculous affection diminishes slowly or not at all. Although the clinical signs may suggest one or other condition as being present, confirmation of the diagnosis can only be assured by biopsy.

Syphilitic Synovitis. Although typical syphilitic synovitis is bilateral, the swelling may start in one knee and remain unilateral for a period up to 6 months. The synovitis always becomes bilateral eventually, and the presence of a positive Wassermann reaction, the freedom of movement in the joint, the absence of all traces of pain or discomfort in the swollen joint, and of the pulpy thickening of the synovial membrane, are usually sufficient to confirm the diagnosis.

Hæmophilia. Swelling of the joint caused by hæmarthrosis can usually be differentiated by the history of previous hæmorrhages, by the thickening of the joint, which is hard rather than doughy, by the history of a sudden complete swelling following some slight accident, and in the old cases by the radiographic appearance of small punched-out areas on the articular surfaces of the affected joint.

Prognosis

Without adequate and continued treatment a knee-joint which has been affected by tuberculous arthritis develops a fibrous ankylosis at or near a right angle, frequently accompanied by sinuses which may persist for years. With efficient treatment the outlook in children is good, as the infection usually terminates as a sound fibrous ankylosis with the joint in extension, or occasionally with a fair range of movement. In the adult the response to conservative treatment is never so rapid or so satisfactory, unsound ankylosis being the usual result of this line of treatment.

Conservative Treatment

Local. The object of local treatment is the elimination of inflammation by rest of the affected tissues; the fixation must be complete and continuous and can be efficiently provided by means of splints or plaster case. If the diseased joint can be immobilized efficiently and, at the same time, left uncovered for inspection and for sunlight treatment, the course of the disease can be studied and regulated. If treatment is begun in the early stages of the disease, before the appearance of deformity, the joint can be adequately and efficiently controlled by means of the Thomas bed knee splint (Fig. 1). In this the joint is left uncompressed but completely immobilized, the patient remaining in bed so long as there are any signs of activity of the disease (Figs. 45*a* and 45*b*).

With Deformity. When the joint is already in deformity the treatment to be adopted depends on the degree of the deformity present and the type of ankylosis between the femur and the tibia. When this union is unsound the deformity may be corrected, either rapidly under anæsthesia or preferably by a slow gradual stretching. The simplest

FIG. 45a.—Tuberculous disease of the Knee-joint and inner surface of the Tibia.

FIG. 45b.—End result of Treatment by conservative means.

method is by the use of the double-ended Thomas splint (Fig. 2), in which pressure is applied at right angles behind the head of the tibia, whilst extension is applied to the leg at an angle slightly less than that of the angle of deformity. If the head of the tibia is already subluxated correction of this deformity is usually complete before the limb is fully straightened. If the correction is carried out slowly, without the application of undue force, there is no fear of spread of the infection to other tissues.

Abscesses. The development of abscesses in connection with a tuberculous arthritis of the knee is more characteristic of the disease in children than in adults. Their presence indicates a low grade of resistance to the infection, and should be taken as a sign of the necessity for prolonged treatment in recumbency. Aspiration is usually successful, but occasionally, on account of the solidity of the abscess contents, nothing can be withdrawn through the needle; nevertheless, every effort should be made to avoid incision when possible.

Convalescent Treatment

When the clinical signs indicate the cessation of activity of the disease with a normal temperature, absence of pain, and the radiographic appearances of recalcification (Fig. 46), recumbency may be changed with advantage to ambulatory treatment. This alteration is

Fig 46 —Tuberculous disease of Knee joint, quiescent, unsound ankylosis

simple, the Thomas bed knee splint being replaced by a caliper splint, with preferably a cloth boot so that fixation of the joint can be continued by day and night

If the caliper splint is made rather too long, little weight is borne through the leg itself, but, as the condition of the knee-joint improves, more weight may be carried through the leg with safety and without

injury to the affected joint. This can be arranged easily by shortening the caliper, or by refraining from lengthening it as the patient grows. The caliper must be worn continuously day and night for a period of at least one year, the boot being removed each day in order that the heel may be rubbed with methylated spirit and powder. If, however, the patient complains of discomfort in bed owing to the pressure of the ring, the caliper may be replaced at night by a long back splint, the removal of one splint and the application of the other being carried out without moving the joint. After a period of 18 months it is usually safe to remove all splintage at night, but if during the night the joint shows a tendency to flexion, complete fixation must be continued for another 6 or 12 months, when another attempt may be made to allow freedom from fixation in bed.

If recalcification and sclerosis of the affected bone is shown by the radiograph, freedom may be allowed for gradually lengthening periods each day. The joint at this stage is usually ankylosed by fibrous tissue, although occasionally a fair range of painless movement is present. Further treatment depends on the progress of the disease; if the ankylosis is unsound and yields to weight-bearing, further support is necessary (Fig. 47), or the fusion should be made sound by performing an arthrodesis of the joint.

Fig. 47.—Laced Leather Splint.

Operations on Tuberculous Arthritis of the Knee

In children all extensive operations, such as excision or arthrodesis, are definitely contra-indicated on account of the probability of injury to the epiphyses of the femur and tibia. Very occasionally a loose piece of necrotic bone may be removed, but it is preferable to avoid operative interference in young patients.

In the Adult. With the adult the problem is different. The patients do not react so favourably to conservative measures; time is of much greater importance, and the possibility of injury to the growing end of the bones has disappeared. It is, therefore, in most cases advisable that the operation of arthrodesis should be performed at the earliest date when recalcification has become evident. The only question of debate is the age at which it is justifiable to perform the operation. After the age of 17 the further growth of the limb is comparatively

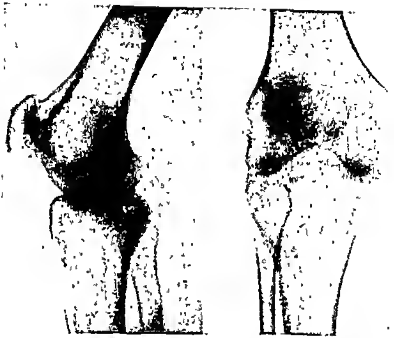


FIG. 48a.—Tuberculous disease of the Knee-joint in an Adult

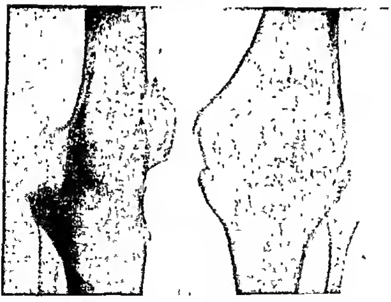


FIG 48b.—Bony Ankylosis following excision of Knee.

slight and deformity does not then develop through epiphyseal injury, and although successful operations are occasionally performed at an earlier age this should be considered as the minimum.

Arthrodesis. Through a U-shaped skin incision with its base upwards, the ligamentum patellæ and quadriceps expansion are divided down to the thickened synovial lining. The ligament and expansion are reflected upwards with the skin flap before the synovial lining is opened. When the attachment of the ligament to the lower border of the patella is defined this bone should be divided by a saw or chisel on the horizontal plane, the posterior half remaining attached to the unopened synovial sac. The dissection of the quadriceps and superficial portion of the patella is continued until the upper edge of the supra-patellar pouch is defined. The pouch, post-patellar pad and the whole of the anterior portion of the synovia can now be removed in one piece without danger of spreading the infected tissue. After dividing the crucial ligaments, and removing the semi-lunar cartilages, the posterior portion of the synovial membrane can be removed by dissection, or, if this is impossible, by scraping the ulcerated surface. The articular cartilage is now removed with part of the underlying bone from the femur and tibia, so that the normal shape of the bone ends is more or less preserved, and the appearance of the joint following the operation is very slightly altered. Any deep areas of tuberculous infection in the bones are cleaned out with a gouge, and the three raw bony surfaces of the femur, tibia and patella can now be placed in apposition. If it were certain that bony ankylosis would occur rapidly it would be preferable to place the joint following operation at an angle of 10 degrees flexion, but on account of the possibility of subsequent union being delayed it is better to immobilize the joint in the straight position. After three weeks a caliper splint is applied, and the patient is permitted to walk about and stimulate union between the roughened bones. The application of a cloth boot, which must be worn day and night, is essential, because by this means fixation of the leg in the caliper is continuous until bony union has been secured (Figs. 48a and 48b), when the splint may be discarded.

Amputation. Occasionally, in the presence of a severe mixed infection, and especially in elderly patients whose resistance is poor, conservative operations hold out little hope of success, and amputation may be the only means of saving life. The operation should not be postponed indefinitely, but should be performed as soon as the clinical signs indicate that general resistance is diminishing

TUBERCULOUS DISEASE OF THE ANKLE AND TARSUS

The Ankle-joint

The primary infection in tuberculous disease of the ankle-joint may occur *in bone or in synovial membrane*. In the latter case the disability is usually attributed to a sprain, following which the joint has gradually become swollen and thickened, while the foot has deviated

FIG. 49.—Tuberculous disease of Astragalus, *focus more posterior than usual*

to a position of deformity. As a rule progress of the disease is slow, but if untreated the swelling increases with the formation of abscesses, which point in the region of the malleoli

When the primary deposit has occurred in bone it can usually be

seen on the dorsum of the neck of the astragalus between the two articular surfaces (Fig. 49). As soon as the ankle-joint itself is affected movement is lost, although this very important sign of rigidity may be difficult to demonstrate on account of the freedom of movement in the sub- and pre-astragaloid regions.

Signs

Thickening and swelling are present round the joint, appearing chiefly on both sides of the tendon achilles and in front of the malleolus. As in all other tuberculous joint affections pain is rarely present and is only elicited by a sudden unexpected strain of the joint. When the disease is confined to the ankle-joint the foot is usually fixed in slight equinus with eversion, which is especially apparent if walking has been permitted.

The Tarsus

Tuberculous disease of the tarsus at first affects only one aspect of the foot, and the clinical appearance varies with the site of the disease. If the inner border is affected, the foot tends to become everted, abducted and somewhat plantar flexed, while disease of the outer tarsus is followed by eversion to a lesser degree. In addition to this deformity of the foot disease of the tarsus produces a clinical picture very similar to that of

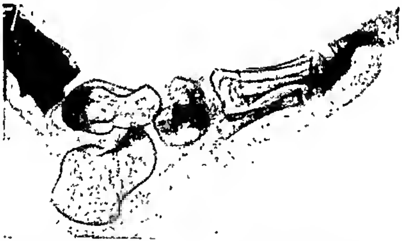


FIG. 50.—Tuberculous disease of the Scaphoid and Internal Cuneiform.

disease of the ankle-joint itself. Thickening and swelling gradually appear over the affected area, the radiograph at first showing an extensive decalcification and later true bone destruction (Fig. 50), the scaphoid and cuboid being commonly involved. Abscess formation is common and unless the area is protected efficiently multiple sinuses are to be expected.

Diagnosis

Little difficulty is experienced in the diagnosis of an advanced case. All the characteristic signs and symptoms of painless swelling and thickening with bone destruction are present, and the aspiration of a quiet abscess or the removal of typical tuberculous material confirms the diagnosis. However, there is often considerable difficulty in deciding the nature of an early case, in which there is a painless enlargement of the inner or outer side of the tarsus, without any radiographic changes In such cases one clinical sign is often of considerable help in making the diagnosis. If the swelling is free from tenderness on pressure the possibility of the condition being tuberculous in origin is definitely strengthened.

Treatment

Tuberculous disease of the ankle-joint or of the tarsus necessitates prolonged fixation of the foot at the optimum position of right angles. Fixation of the foot in a splint (Fig. 51) is preferable to its enclosure in plaster of Paris. The use of plaster is based on the more complete immobilization in the affected area, but in spite of its excellent mechanical fixation serious complications are frequently seen following its use. The fixation of an infected ankle in a plaster

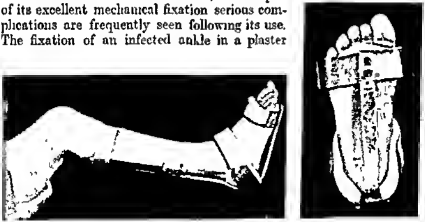


Fig 51 —Skeleton Splint for the Foot used in tuberculous disease of Foot and Ankle

case is frequently followed by the formation of abscesses and the opening up of sinuses, even whilst the foot is completely immobilized and cannot be inspected. The complications occur very rarely following the use of an efficient splint, in which the affected area can be exposed to the air and sunshine.

Its advantages are obvious when sinuses are present, as the dressings may be easily changed without removal of the splint, and without allowing movement at the affected joint. If deformity is already present,

correction by gradual alteration of the angle of the splint presents little difficulty. No definite time limit can be given as to the period of fixation necessary, but, as a rule, after 18 months recalcification appears (Fig. 52), and walking with protection may then be permitted.

FIG. 52.—End result of treatment by rest and immobilization.

Operations for Tuberculous Arthritis of the Ankle

In children operation of any type is usually inadvisable, but occasionally where the disease has been neglected and sinuses are widespread bringing the risk of mixed infection and amyloid changes, an amputation may be a life-saving measure.

In the adult excision of the disease is occasionally advisable, but only when carried out under favourable conditions which include the presence of recalcification in the diseased area and the absence of the evening rise of temperature. The operation involves widespread opening up of the area and removal of all infected tissue, clearing out the articular surfaces of the tibia, astragalus and fibula, followed by fixation until bony union is sound. Walking may then be permitted with the use of an outside iron as advised after conservative treatment.

As the disease so often starts in the astragalus the removal of this bone is often undertaken in an effort to remove the seat of infection, but the result of the operation is usually unsatisfactory as widespread infection is often present from an early stage.

Amputation is only performed in children as a life-saving procedure, and with efficient conservative treatment is only necessary when the disease is accompanied by extensive tuberculous infection of lungs or kidneys. In elderly patients, however, where the disease is progressing in spite of efficient conservative treatment, amputation is the only possible form of treatment and should be undertaken without delay.

CHAPTER IX

TUBERCULOSIS OF THE SPINE AND SACRO-ILIAC JOINT

THE SPINE

Pott's Disease

In his original paper Pott described a condition of a paraplegia associated with deformity of the spine. It has long been recognized that the angular deformity, which is the characteristic clinical sign of the disease, is the result of the destruction of the bodies of one or more vertebræ, which have become affected by tuberculous disease. Owing to this destruction of bone on the anterior portion of the column, the spine above the site of the disease falls forward, leaving the spinous processes in the diseased area to form a prominent knuckle. Almost 45 per cent of all tuberculous bone and joint affections occur in the spine, this area being by far the commonest single site of the disease. The lower dorsal and upper lumbar areas are more frequently involved than any other region, the probable explanation being that in this area the mobile lumbar spine joins the more rigid dorsal section, strain and trauma there having their greatest effect.

In the figures obtained from the Royal Liverpool Children's Hospital the disease was found to occur at the different levels in the following proportions:

Dorso-lumbar region . . .	46 per cent
Lumbar region . . .	22 ,, ,,
Dorsal region . . .	13 ,, ,,
Cervical region	10 ,, ,,
Lumbo-sacral and sacro iliac region . .	9 ,, ,,

In children the primary deposit of tuberculous infection usually occurs on the upper or lower surface of the body of the vertebra under the epiphyseal plate. From this site the infection spreads into the neighbouring intervertebral plate, which is rapidly destroyed with a consequent loss of joint space and involvement of the adjacent vertebral bodies. In the older child and in the adult the original infection occurs more commonly in the anterior aspect of the vertebral body, producing first a collapse of the involved vertebra, and later a destruction of the intervertebral discs and infection of the neighbouring vertebræ. On rare occasions the disease may extend up and down the anterior aspect of the vertebral bodies as a tuberculous periostitis causing little bone destruction, but, as a rule, the area of infection gradually increases, the cancellous bone is replaced wholly or partly by granulation tissue, and

the strength of the vertebral body being lost its collapse becomes inevitable. Exceptionally the disease may remain confined to one vertebral body as a localized focus, round which there is a certain amount of sclerosis, but, as a rule, it extends to the neighbouring bodies and may ultimately involve as many as 6 or 7 vertebræ—a condition which inevitably leads to considerable diminution of the length of the spine and to excessive deformity (Fig. 53). Very occasionally the laminæ or spinous processes, or the intervertebral joints, may become involved by the disease, while the bodies of the vertebræ remain unaffected, but such conditions cannot be classified as true Pott's disease, and do not lead to the chain of signs and symptoms which usually follow on the destruction of the body of the vertebra

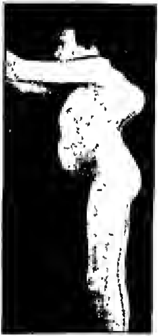


Fig 53.—Advanced tuberculous disease of the Dorsal Spine.

As in every other pathological condition, the disease may be arrested at any stage; early cessation may be due to efficient and early treatment, to a comparatively mild type of infection, or to an abnormal power of resistance on the part of the patient Thus the disease may become encapsulated by a thick wall of fibrous tissue without producing an extensive bone destruction. If only one vertebral body is destroyed the subsequent collapse results in the approximation of the anterior border of the bodies of the vertebræ above and below, but if several bodies take part in the destructive process, the collapse is so extreme that the anterior surface of the healthy body above the disease lies in contact with the upper surface of the tuberculous mass or of the healthy vertebral body below. Repair is usually accomplished by an ankylosis which is partly fibrous, partly cartilaginous and partly bony, and this is often reinforced by calcification of the thickened tissues round the site of disease. When the disease is of long standing a fibrous and bony ankylosis usually develops between the laminæ, pedicles and articular processes, and by this fusion of the vertebral processes the weakened spine is efficiently supported, thus preventing further deformity.

Prognosis

Of all the forms of tuberculous arthritis that which involves the spine is undoubtedly the most serious on account of the importance of

the structures involved and of the organs which lie in close contact with the site of disease. The prognosis varies also with the degree of deformity. In the typical "Hump-back" the thoracic and abdominal contents are compressed, the blood vessels are distorted, respiration is rendered more difficult and less extensive, circulation is interfered with to such a degree that a secondary cardiac hypertrophy develops, leading to the possibility of a fatal result of any intercurrent disease. It is, therefore, impossible to do more than make a rough guess of the percentage of fatal results which are caused directly or indirectly by Pott's disease, although statistics show that 5 per cent of the patients die during the course of treatment of the disease in its active stage.

Symptoms and Signs

Occasionally while the tuberculous focus is localized to the body of one vertebra, the patient complains of an aching pain at the site of the lesion, but, as a rule, severe pain is uncommon at any stage of the disease. Even before the appearance of deformity it is noticed that the patient walks with a peculiar, tender, stooping gait, as if the floor was covered with fragile articles which might easily be broken. Associated with this there is the constant complaint of tiredness, and usually the statement that riding in a tram or bus causes acute discomfort.

If the patient is examined at this stage it will be found that although no deformity is present, movement of the spine is lost over the region of the disease and for some distance above and below this point. Usually, however, when the child is brought for examination deformity has already appeared as a more or less sharp antero-posterior knuckle. Accompanying the deformity an abscess may be discovered in the pelvis, back or chest-wall, with frequently a contraction of one or both psoas muscles, preventing full extension at the hip-joint.

Pain and Tenderness. If pain is present in Pott's disease it is not generally localized to the area of bone destruction, but is referred to the termination of the nerves which send small filaments of supply to the affected vertebral bodies. Thus, such referred pain may suggest appendicitis or sciatica, but the differential diagnosis should always be easy if the examination of the patient is complete. There is, as a rule, no tenderness on pressure or percussion over the spinous processes of the affected vertebræ, but the methods of examination by percussion over these prominent spinous processes, or by percussion on the head, in an effort to produce referred pain at the site of disease, cannot be condemned too strongly. If these methods are carried out sufficiently firmly to produce pain they will certainly lead to injury at the site of disease.

COMPLICATIONS

Abscess Formation. The presence of an abscess as a complication is the almost invariable rule in Pott's disease. The abscess may remain small and localized to the area of disease, the wall in such cases becoming sclerosed, thickened, and in many instances calcified, being usually recognized in the radiograph as a shadow surrounding the area of disease (Fig. 54) The abscess may, however, increase rapidly in size and extend in various directions, according to the level of its site of origin.

The abscess-wall is formed of dense fibrous tissue, lined by a pinkish layer of granulation tissue. Its contents are usually semi-solid and are composed of broken-down tissue cells, serum, leucocytes and masses of caseous material, with occasionally a small flake of necrotic bone. The abscess may cause considerable interference with the functions of neighbouring organs, especially when it is of large size, or it may occasionally become infected with other organisms from the skin, bowel, lungs, etc., the occurrence of this secondary infection being heralded by a considerable rise of temperature, increase of pain, and redness if the abscess approaches the surface.

The abscess may remain localized to the area of disease or may extend widely and appear at a considerable distance from the original focus. The point of appearance in any area is determined by the presence of fascial attachments, blood vessels, muscles, etc., which govern its line of spread Thus, with disease in the cervical region, the abscess may project forward behind the prevertebral fascia, appearing in the mouth as a retro-pharyngeal abscess, or it may extend laterally and point behind one or other sterno-mastoid muscle. If it pierces the prevertebral fascia it may appear in the mouth, or in the side of the neck in front of the sterno-mastoid muscle. Occasionally it spreads round the sides of the vertebral bodies and appears close to the spines of the cervical vertebræ.

With disease of the thoracic region the abscess may remain localized on the front of the vertebra in the area of disease. It may perforate the anterior longitudinal ligament and occupy the posterior mediastinum, occasionally causing considerable interference with respiration or swallowing. As with disease of the cervical spine, it may extend backwards round the sides of the vertebræ, and appear on the dorsum, or it may extend laterally accompanying the intercostal vessels and nerves, appearing on the surface in the mid-axillary line or at the lateral margin of the sternum.

With disease of the lumbar spine the abscess frequently enters the sheath of the psoas muscle, tracking downwards until it appears below Poupart's ligament on one or other sides of the femoral vessels, while

FIG. 54.—Tuberculous disease of the Spine with a large calcified Psoas Abscess

occasionally it joins the femoral vessels in their sheath and may point at the inner side of the thigh, or in the popliteal space. It sometimes spreads under the sheath of the iliacus muscle and may appear on the surface close to the anterior superior spine of the ilium. As in the case of the disease in the cervical and dorsal regions, abscesses in this region *may track backwards and* appear on the dorsum, usually to the outer side of the erector spinæ muscle, or they may spread with the vessels and appear below the last rib on the surface of the abdominal wall above the crest of the ilium.

Paraplegia. This serious, but fortunately comparatively rare, complication may appear at any stage of the disease, and is usually an indication of inefficient treatment, either in the early active stage, or, more frequently, in the convalescent stage when efficient treatment is equally necessary. It is, as a rule, a late complication, but may be present even before the appearance of deformity, in such circumstances generally resulting from the presence of the primary focus on the posterior surface of the vertebral body. As a rule, its onset is comparatively slow; the patient walks with a jerky spasmodic gait and is rather unsteady. This loss of muscular co-ordination gradually increases and walking becomes worse; examination at this stage shows considerable increase in the knee jerks and the presence of ankle clonus. Usually both lower limbs are equally affected, but occasionally the paraplegia is irregular and one side may be involved to a greater extent than the other. As a rule, sensation remains normal, although in extreme cases at a late stage all feeling may be lost below the level of the lesion. Control of bladder and bowel is, as a rule, maintained through the whole course of the paraplegia, but occasionally control is lost and incontinence appears. As the bladder fills, the reflex centre is stimulated and the urine is evacuated. Control of the sphincter ani is, however, often maintained, even in the absence of control of the bladder.

Liability to Paraplegia. The lumen of the spinal canal varies very considerably at the different levels, thus it is widest in the cervical and lumbar regions, which are the areas of the spine where there is the greatest mobility, whilst it is distinctly smaller in the mid- and lower dorsal area, in which the movements of the spine are comparatively slight.

From the records of a large number of patients suffering from paraplegia it is found that in 60 per cent the condition is associated with disease of the 5th–10th dorsal vertebræ. This area has, in fact, been described as the paraplegic area of the spine on account of the relative frequency of the occurrence of this serious complication. In the other 40 per cent the disease was present in the upper dorsal and cervical region 22 per cent, and in the lumbar region 18 per cent, so that the

size of the lumen of the spinal canal bears a very distinct relation to the occurrence of the paraplegia.

Cause of Paraplegia. Examination of a series of post-mortem specimens of patients who suffered from paraplegia demonstrates quite clearly that the condition is almost invariably caused by pressure on the cord of a tuberculous abscess, or mass of granulation tissue, which has extended into the canal from the site of the disease. This mass remains almost invariably extradural, the thickening and inflammation of the dura mater and meninges, which are usually present at the site of pressure, being caused by the surrounding inflammatory reaction and not by a spread of tuberculous infection. Very occasionally the dura mater, the meninges and the cord itself have been shown to be infected by the spread of the disease and exhibit definite tuberculous infiltration, and even abscess formation. It may be stated as a general rule that paraplegia is never caused by the pressure of the bony angle formed in the spinal canal by the collapse of the vertebral bodies and the falling forward of the spine above the disease (Fig. 55). There is always sufficient room for the cord, even in the deformed canal, although very occasionally a definite necrotic bony mass may be pushed backwards from the diseased vertebral bodies, and may be the direct cause of the paraplegia.

Prognosis. In the absence of efficient treatment the prognosis is distinctly grave, but if suitable treatment is adopted at an early stage the prognosis is good, especially in children. The possibility of recovery depends largely on the period during which the paraplegia has been present. Thus, in 15 cases in which treatment started within 2 months of onset of paraplegia, complete recovery occurred in 11, and partial recovery in 4, while in 9 cases where the paraplegia had been present for more than 12 months the result was a partial recovery in 5 cases only.

Treatment of Pott's Disease

As with every other type of tuberculous arthritis the essential factor in treatment is complete rest of the affected joints, combined with all other methods of improving the general health, such as suitable nourishing diet, open air, etc., which act indirectly on the disease by improving the patient's general resistance. Effective immobilization can be secured by using one of the many types of frame in common use, or by the plaster shell, which is composed of two separate sections, one on the anterior and one on the posterior aspect of the body, on which they have been closely moulded. By the use of one or other section the patient can be treated lying on the back or on the abdomen.

Adequate fixation is given by the use of a frame (Fig. 6) on which the patient lies recumbent with the legs bandaged firmly to prevent

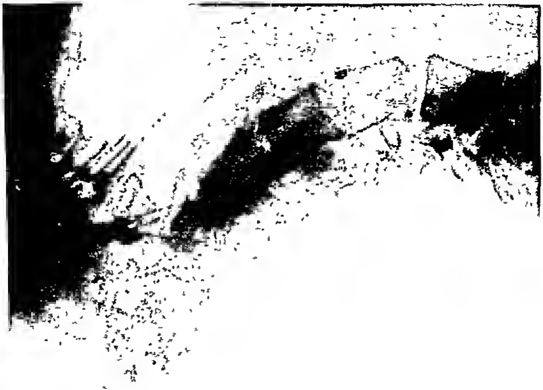


FIG. 57.—Extreme Kyphosis due to Tuberculous Arthritis of the Spine without Spinal Cord involvement.

movement of the spine, and with the arms free. The side bars of the frame prevent lateral movements, and if necessary the head can be strapped to the headpiece, thus providing a more efficient rest to the affected area. This extra fixation of the head is usually necessary when the disease involves the cervical, upper or mid-dorsal regions. When the head is left free the child usually twists and turns so freely that the diseased area never obtains the necessary rest.

Attention to the skin of the back and prevention of pressure sores is possible without removing the patient from the frame, and with the minimum amount of movement at the diseased area of the spine. The skin is protected by gentle rubbing of the areas of pressure with a cloth impregnated with methylated spirit, which prevents softening and dampness of the skin; the excess of spirit is removed by another cloth and the area is then dusted lightly with powder. If this régime is carried out conscientiously and carefully, at first three times daily, and later at least once per day, there is no fear of pressure sores, nor is there any necessity of interrupting the course of treatment by removing the patient from the frame. Attention must be paid to the feet, which may become deformed owing to contraction of the calf muscles; this complication, which is much more liable to occur in adult patients, is very seldom seen in children. It may be prevented by gentle daily stretching of the calf muscles, the leg being held firmly while the foot is fully dorsiflexed, and by encouraging the patient to move the foot fully in all directions. This simple procedure, if carried out every day, will prevent the contraction, and is preferable to the application of rigid foot-rests, against which the patient can lever his body, and so cause movement of the diseased area.

Period of Fixation. In children uninterrupted recumbency should usually be continued for 18 months to 3 years, but removal from the frame even then should be contingent on improvement in the condition of the diseased vertebræ. In the acute stage, when the disease is progressing, the radiograph shows the affected vertebræ to be decalcified with no limiting area of bone sclerosis (Figs. 56 *a–d*). As a result of immobilization the inflammatory process diminishes, the decalcification becomes less, and gradually recalcification appears with an eventual ring of sclerosis around the affected bones. Cessation of the recumbency should depend upon the absence of pain, the presence of a normal temperature, of normal tendon reflexes and the appearance of recalcification and sclerosis at the site of disease, however long the period of waiting may be until these favourable signs are present. This ideal line of treatment can be carried out safely in the case of children, but with adults prolonged recumbency is not so well tolerated and ambulatory treatment should, as a rule, be instituted before recalcification of the diseased area is evident.

Albee the affected area is stabilized by means of a bone graft, taken from the tibia, and implanted into the *spinous processes which have* been split longitudinally for its reception.

The aim of such operative treatment is the more efficient fixation

FIG. 57.—Tuberculous disease, compensatory curves above and below Kyphos.

of the affected area and consequently the diminution of the period of recumbency necessary for cure of the disease. When these methods were first introduced it was suggested that, *as soon as the bony fusion* of the spinous processes and laminæ was complete, the patient's normal activities might be resumed. This belief is not now held, as in many

instances early activity was followed by the development of psoas or lumbar abscesses, proving the truth of the principle that so long as activity of the disease is present activity of the patient is contra-indicated.

The operations have, however, a very definite place in the treatment of Pott's disease. When the disease has affected one side of the vertebral body more than the other it is extremely difficult to control the tendency to increasing lateral deviation of the spine, and in such circumstances—after the disease has been adequately treated by conservative means—a bony fusion of the affected area is more efficient in preventing deformity than any form of splint. Again, when Pott's disease has healed with a definite knuckle deformity, and without bone formation at the site of disease, symptoms of aching and pain, due to yielding of the fibrous tissue, may persist for a very long time. These symptoms usually disappear when a posterior support (Fig. 8) is worn, but the operation of bony fusion is occasionally justified if the pain returns when the support is removed, especially when the area of disease is situated at a high level and there is in consequence great difficulty in fitting an efficient support. The after-treatment is identical. The patient remains recumbent for 6–8 months until bony union is complete before normal activities are resumed, the operation area being protected by the use of a posterior support for the following 6–12 months.

Convalescent Treatment. When all indications of activity have disappeared from the area of disease, and it is considered safe for the patient to assume the erect position, it is essential to support the site of disease by some form of frame or plaster case, even in those cases where a successful operation has been performed and a bony fixation of the spine has resulted. The posterior support, shown in Fig. 8, is the most simple and efficient type of ambulatory splint; its sole object is the prevention of the antero-posterior bending of the diseased spine, no attempt being made to give vertical support which many have mistakenly attempted to obtain by means of axillary posts. The essential features of the support are the firm fixation of the pelvis by means of the broad pelvic strap, and the pulling back of the shoulders to the frame by means of the shoulder-straps. When properly designed the support is so constructed that on tightening the pelvic strap the upper part of the frame stands slightly away from the spine, which is then pulled back to it by means of the arm-straps, thus preventing the normal antero-posterior strain from acting on the diseased spine.

The great advantage of the posterior support over plaster casts is the entire absence of constricting bands over the chest and abdomen. Full respiratory movements are as essential in the convalescent as in the active stages of the disease, and any restriction of the normal inlet constitutes a grave injury to the patient's health.

The support is worn day and night and is only removed once a week

in order that the back may be washed, the technique to be followed in its removal is already described in Chapter II. When the disease is situated at or above the level of the 6th dorsal vertebra, additional support is always necessary. This is given effectively by means of the Thomas collar, which can be attached to the posterior support and prevents the sinking downwards of the chin which would otherwise occur.

The support and collar are worn continuously for at least 2–3 years, and are only removed when complete consolidation has occurred, when no tenderness or pain can be elicited, and when all signs of complications have been absent for at least 12 months.

Treatment of Complications

Paraplegia. The most satisfactory results in the treatment of paraplegia follow on the immobilization of the patient in a position of recumbency, and this method should always be employed in the early stages of the disease for a period of 5–6 months before any other form of treatment is considered. If the immobilization is carried out effectively no other form of treatment is required in at least 85 per cent of the early cases, but in the remainder in whom the signs of pressure do not disappear, the question of operation must be very carefully considered.

The object of any operation is the relief of the spinal cord from the abnormal pressure to which it is being subjected, and this object may be attained either by a laminectomy, which reduces the pressure in the canal but does not remove the tuberculous abscess or granulation tissue which is causing the increased pressure, or by operation of costo-transversectomy, in which an attempt is made to drain the abscess in and round the canal by opening down to it along the side of the diseased vertebræ.

If efficient conservative treatment has been carried out the chance of recovery is not greatly improved by any form of operation, as in these patients the meninges or the cord are probably already involved by definite tuberculous infection.

Costo-transversectomy. An incision, 4 inches in length, is made to the right of the spinous process of the affected vertebræ; the muscles are stripped from the side of the spinous processes and from the back of the transverse processes, until the joints between the ribs and transverse processes are defined. Two of these joints at the apex of the curve are exsected and the finger, or a blunt elevator, is passed carefully downwards and inwards until the abscess area is reached; when the abscess has drained, the incision should be closed with deep and superficial sutures. The advantages of this operation are obvious, the spine is not weakened by the removal of the laminæ and spinous processes which, in the presence of disease of the vertebral bodies, form the chief

support for the spinal column. The procedure has, however, the great disadvantage that, if the paraplegia is not due to the presence and pressure of an abscess, but to a mass of granulation tissue only, relief cannot follow this simple opening.

Laminectomy. The muscles are stripped from the sides and back of the spinous and transverse processes of the affected vertebræ through an incision made to one or other side of the middle line. The laminæ are now cut through by means of a fine saw or curved forceps on each side at the base of the transverse processes. The mobile portions of the laminæ, with their spinous processes, are now removed by cutting through the supra- and inter-spinous ligaments, and the tension in the spinal canal is thereby relieved at the area of disease.

The operation of laminectomy is naturally more effective in providing relief from pressure, but it entails considerable weakening of the spinal column through removal of the only portions of the vertebræ which have not been affected by the destructive process. A suggestion has been made that this weakening of the spine, following a laminectomy, may be prevented to some extent by the application of a single or double bone graft bridging the gap, but this procedure has the disadvantage of predisposing the patient to a secondary paraplegia if there is an increase in the size of the abscess, or granulation tissue mass which produced the primary lesion.

SACRO-ILIAC TUBERCULOSIS

Tuberculous infection of this joint is found as frequently in the adult as in the child, and its onset is usually slow and insidious. The first sign may be the appearance of an abscess over the region of the joint before there are any signs or symptoms, which would indicate the presence of infection. As a rule, however, the patient complains of pain in the lower part of the back and down the course of the sciatic nerve for some time. Early in the course of the disease it is noted that the patient tires after a slight exertion. Examination of the spine frequently shows a well-developed lumbar scoliosis which remains fixed and does not alter to any extent, even in recumbency. At a later stage, the patient walks very carefully, the feet are shuffled along the ground and are not raised from the floor at any part of the step. Movements of the spine are distinctly limited, and forward bending is particularly diminished, especially when the knees are kept straight.

Diagnosis. The diagnosis of tuberculous arthritis of the sacro-iliac joint is often very difficult, especially in the early stages. The radiograph (Fig. 58) may show little bone destruction, and even when early bone changes are present it is by no means easy to differentiate them from the normal irregularity of the sacro-iliac joint. With more

FIG 58.—Tuberculous disease of Sacro iliac Joint, also focus in symphysis pubis

extensive bone destruction and occasionally when subluxation of the joint is present no difficulty is experienced.

As a rule, abscess formation occurs at some stage of the disease, and when present is more likely to extend forward through the comparatively weak anterior ligaments than backwards. An abscess can therefore be felt more commonly on the anterior than on the posterior aspect of the joint.

Prognosis. The prognosis varies with the age of the patient, when occurring in childhood the outlook is better than in adult life, but at any age the prognosis is not so good as in tuberculous disease of any other level in the spine. The period of recumbency necessary for cure may extend over 4 or 5 years, and if a sinus develops, gross infection is common and is associated with rapid loss of weight and occasionally with amyloid changes.

Treatment

In every instance treatment by fixation in recumbency should be insisted on, at least until the patient's resistance has improved, and until some signs of bone sclerosis have appeared. Such fixation can be carried out on a double frame (Fig. 6), or by plaster or celluloid casing extending from the shoulders to the ankles.

The difficulty of the immobilization of this joint lies in the impossibility of obtaining complete rest by any form of fixation. Each time the bowels are moved there is necessarily some strain and movement of the affected joint, but by fixation in recumbency the strain of weight-bearing is removed.

In the adult especially, and in the case of children where improvement has not shown itself following 18 months' fixation, operative treatment must be carefully considered.

Operative Treatment. Many types of operative treatment have been practised; those in most common use being the partial excision of the disease, as advised by Picqué, and the various methods of stabilizing the diseased joint by extra- or intra-articular arthrodesis.

Picqué's Operation. The joint is approached through an incision 6 inches long, extending along the crest of the ilium from the posterior inferior iliac spine. The outer side of the ilium is cleared down to the sacro-sciatic notch, and the posterior portion of the ilium—which has

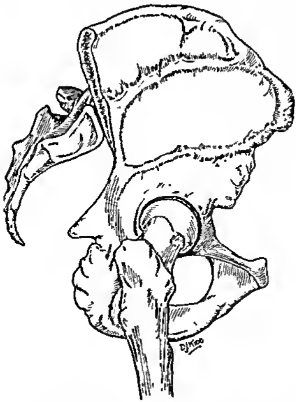


FIG. 59.—Picqué's operation showing removal of posterior portion of Ilium and exposure of articular surface of the Sacrum.

been released previously by division of the posterior sacro-iliac ligaments—is removed by an incision through the bone, extending vertically from the crest to the sacro-sciatic notch (Fig. 59). After this removal of the infected ilium the necrotic area on the side of the sacrum can be cleared out and the muscles sewn over the field of operation. As a rule the bone necrosis affects chiefly the lower margin of the joint, but occasionally it may be confined to the upper sector when a modification of the complete operation is possible. A small portion of the lower margin of the ilium, above the sacro-sciatic notch, may be left in position with the advantage that the post-operative stability of the joint is greatly increased. Subsequently rest in the recumbent position for 4–6 months is necessary, and when walking is resumed a tight belt, holding the pelvis firmly, is of great advantage in stabilizing the excised joint

Extra-articular Fixation. A diseased sacro-iliac joint may be stabilized effectively by extra-articular fixation in the manner devised by Verrall, in which the posterior portion of each iliac bone is fused to the sacrum. In this method after removal of a broad graft from the tibia, holes, sufficiently large to allow passage of the graft, are made in the posterior portion of each ilium at such a level that the line joining them passes through the superficial portion of the back of the sacrum. In this space the graft is placed and the patient retained in the recumbent position until fusion has occurred between the three bones.

Intra-articular Fusion. The method of intra articular fusion of the sacro iliac joint devised by Smith Petersen and described in Chapter XIII may also be used for the fixation of a diseased sacro-iliac joint.

The operation when employed in this condition has the disadvantage of opening up infection which may be easily stimulated to activity.

CHAPTER X

TUBERCULOSIS OF THE SHOULDER, ELBOW AND WRIST

Tuberculous arthritis of any of the joints of the upper limb shows many important points of difference from the same disease occurring in a weight-bearing joint of the lower limb.

In the upper limb the onset of the disease is always peculiarly slow and insidious. Some slight aching may be present, but as a rule no pain is experienced until the disease is fully established. The patient usually complains in the early stages of a gradually increasing stiffness of the joint, steadily progressing until complete rigidity is present. The average age of onset of the disease in the upper limb is also very different from that in the lower limb. In the lower limb the first signs of the disease usually appear before 5 or 6 years of age, while in the upper limb the signs of arthritis appear, on the average, at 8–10 years, disparity in these figures being due to the comparative frequency with which the joints of the upper limb are affected in the adult.

TUBERCULOUS ARTHRITIS OF THE SHOULDER-JOINT

The site of the primary infection is found, as a rule, as a primary deposit in the head of the humerus, although the glenoid cavity or neck of the scapula may, on occasion, show the first signs of destruction. The infection soon spreads from the bone into the joint cavity, and all the articular structures become eroded and infiltrated. The destruction is rapid, the decalcification extensive, while the head of the humerus is firmly pressed against the scapula by the protective spasm of the attached muscles.

Abscess formation is of comparatively rare occurrence, and an outstanding feature of the disease is the absence of much swelling or thickening of the joint. This feature of shrinkage rather than swelling of the affected joint has given rise to the title "Caries Sicca," typical examples of which occur more commonly in elderly patients, although not unknown among children. Caseous infiltration of the bones and of the synovial membrane is widespread, and small areas of detached necrotic bone may be found in the region of the obliterated joint cavity. An abscess is occasionally formed in the course of the disease, and when present it usually points under the skin on the anterior aspect of the joint to the inner side of the anterior border of the deltoid. If allowed to burst on the surface mixed infection may occur with widespread glandular involvement.

(a)

(b)

FIG. 60.—Extensive disease of the Shoulder, (a) active, (b) cured

Symptoms and Signs. The first definite complaint of trouble in the joint is usually a feeling of discomfort when lying on the affected side. The patient finds that it is much more comfortable to lie on the back or on the normal side, while if he turns on to the affected side during sleep the pain produced is quite sufficient to waken him. Night starts, which are frequent in disease of the joints of the lower limb, are seldom complained of in connection with joints of the upper limb. On examination the whole shoulder-joint seems to be shrivelled as compared with the other side, and all movements of the joint are diminished or absent.

Radiographic Appearances. The joint space is obliterated, the articular surfaces of the humerus and glenoid are destroyed; there is no new bone formation round the site of disease, and decalcification is present to an extreme degree in all the affected bones (Fig. 60).

Prognosis. The prognosis is on the whole good. In a few instances where tuberculous arthritis is associated with a widespread phthisis the disease is rapidly fatal, but, in the absence of grave pulmonary complications, the disease usually progresses satisfactorily, leaving a fibrous ankylosis.

Treatment

As ankylosis is the invariable result of the disease, treatment should have as its object the provision of this ankylosis at an angle which will be most useful to the patient, so that, in the absence of all movements at the shoulder-joint, the muscles moving the scapula may act through the rigid joint, thereby providing a useful range of movement for the arm (Fig. 61). In children this optimum angle is found to be 80 degrees abduction, and 20 degrees in front of the plane of the body, whilst in adults an abduction of 60 degrees is the extreme limit to be aimed at for optimum position. The reason for the difference in these angles in the adult and in the child lies in the greater mobility of the scapula in the child as compared with the adult. If the arm is fixed at too great an angle of abduction, adduction is lost, and the patient must keep the arm constantly away from the side, giving an appearance of deformity, and causing a constant strain on the joint.

The position of abduction is most easily maintained by the use of the wire abduction frame shown in Fig. 10. Its lower margin bears weight on the outer side of the thigh between the crest of the ilium and the great trochanter, thus pressure sores and abdominal discomfort do not follow its application, even when long continued. The frame may be worn continuously by a child for 18 months to 2 years without any great discomfort, but a similar prolonged period of fixation is almost unbearable to an adult, especially to one who is rather fat. In such

circumstances, treatment may preferably be carried out with the arm hanging by the side, the forearm and wrist supported by a sling, allowing ankylosis of the joint to occur in the position of extreme adduction. When the ankylosis is complete, improvement in the position may be obtained by a small wedge osteotomy from the outer side of the humerus, or by an arthrodesis of the joint in a corrected position.

FIG. 61.—Tuberculous disease of the Shoulder, sound ankylosis in good position

Operative Treatment

Operation on a shoulder infected by tuberculous arthritis has as its sole object the alteration of an unsound fibrous yielding ankylosis into a sound bony union, which will retain the position of the arm against the force of gravity. The operation is advisable when aching persists, or when the stability of the ankylosed joint is insufficient for the patient's normal activities. It should only be performed at a late stage in the disease when recalcification of the affected bones has become evident, and it should never be employed in the acute early stages when the tissue resistance is at its lowest.

Arthrodesis of the Shoulder-joint. A horseshoe incision is made on the outer aspect of the joint starting in front at the coracoid process, passing down across the outer border of the deltoid, and terminating posteriorly at the level of the spine of the scapula. The deltoid muscle is cut through and turned upwards to allow an uninterrupted view of

all the joint structures (Fig. 62). The infected capsule and perisynovial tissues are completely removed and, after clearing off the articular cartilage and diseased bone from the head of the humerus and the glenoid cavity, these bones are approximated and the freshened acromion process is partly cut through near its base and turned down so that it lies

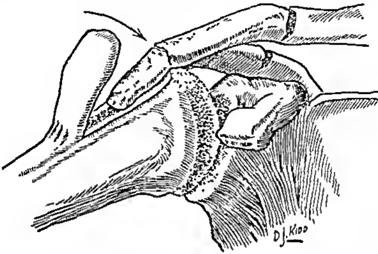


FIG. 62.—Arthrodesis of Shoulder-joint showing Acromion process inserted into gutter of greater tuberosity of Humerus.

in a prepared raw surface on the outer side of the humeral head. The arm, shoulder and chest are firmly encased in plaster, which is retained until union is complete; this period may vary from 3 to 6 months, but when it is evident that union has taken place, freedom is given, at first for a short period, and later for gradually increasing intervals.

Extra-articular Arthrodesis. Operative fixation of the diseased joint is also possible as an extra-articular procedure, without opening the infected capsule, by the implantation of a bone graft from the acromion process to the outer aspect of the shaft of the humerus. The operation aims at stabilizing the joint during the period of activity or after the formation of a weak fibrous ankylosis. The results of this procedure are very rarely satisfactory, and do not as a rule justify the surgeon's enthusiasm, as absorption of the bone graft frequently occurs.

TUBERCULOUS ARTHRITIS OF THE ELBOW-JOINT

As in the shoulder-joint, the primary infection here is usually found in one of the bones, and of these the most common site is the sigmoid *cavity of the olecranon process* (*Fig.* 63). The soft tissues are involved

FIG. 63.—Tuberculous disease of Elbow showing focus in greater sigmoid cavity.

at an early stage and considerable swelling can be seen and felt, particularly on the posterior aspect, where soft fluid collections project on both sides of the triceps tendon. Pain, in the absence of movement, is slight during the whole course of the disease, but limitation of movement in all directions is present from the earliest stage. Abscess formation is of common occurrence, and without efficient treatment a sinus may develop at the inner or outer side of the triceps insertion. *The joint is* always swollen on account of the soft tissue infiltration, and its apparent size is increased by the muscle atrophy in the arm and forearm.

TREATMENT

The simplest and most efficient form of treatment for tuberculous arthritis of the elbow-joint is the simple collar and cuff method of Thomas (Fig. 64). Here, the fixation and rest, although only partial, are sufficient to promote healing and to prevent pain.

Extension of the arm, with the object of separating the affected bones, is never advisable, and when attempted does not improve the condition nor shorten the period of disability. Diminution of the normal range of movement in the joint is the invariable result of the disease, although a range of 10–30 degrees of painless active movement is commonly obtained. Occasionally a very much greater range is seen, while true bony ankylosis occurs very rarely, even in the presence of a mixed infection of the joint with many sinuses.

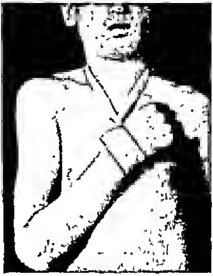


FIG. 64.—Collar and Cuff used in treatment of tuberculous disease of the Elbow joint.

Operative Treatment

Excision of the joint in the acute stages of the disease was formerly the common method of treatment. It necessitated such a widespread removal of infected bone that an unstable flail elbow was the common sequel of the operation If excision is considered suitable it should only be used when recalcification and sclerosis of bone show that the tissue resistance is active and that the limits of the disease are well defined.

Operation. Through a 7-inch straight median posterior incision the lower portion of the triceps is split and the insertion stripped laterally from the upper and posterior portion of the olecranon and shaft of the ulna. The soft tissues are cleared off each side of the lower end of the humerus and the upper portion of the ulna and radius, especial care being taken to protect the ulnar and musculospiral nerves from injury during this dissection. By acute flexion of the elbow the ends of the three bones are presented through the incision, and, after removal of all the infected tissues, a straight saw-cut is made through the shaft of the humerus above the condyles, and through the upper portion of the radius and ulna at the level of the lower border of the sigmoid cavity. The cuts are made transversely at such levels that, after removal of the ends of the humerus, radius and ulna, a gap of 1½ inches only is left between the divided bone-ends when the arm is gently pulled in extension. Any infected soft tissues which have been missed previously are now removed, and the wound in the triceps expansion and skin is sewn up tightly.

For the first 10 days after the operation the arm is kept in the extended

position in order to prevent the immediate approximation of the roughened bony surfaces. After this period, during which the raw surfaces have become coated over by early fibrous tissue, the arm is brought in stages into a position of right-angled flexion. The remainder of the treatment is carried out as in the conservative method with the wrist slung from the neck without support to the elbow-joint (Fig. 64). Active movements are encouraged, and support of the joint is continued until muscular control has been regained and the elbow can be maintained voluntarily against gravity.

Arthrodesis of the Elbow-Joint. If, in spite of prolonged support of the elbow-joint, the stability is still inadequate, *bony fixation may* be attempted at a late stage of the disease. The joint having been widely opened and all the diseased tissue removed, the infected articular cartilages and subjacent bone are cleared, and the roughened bony surfaces approximated. Further fixation can be gained by the use of a tibial bone graft, extending from the humerus to the upper portion of the ulna. Following the operation the joint is protected for 6 months, and full use is permitted when bony union can be seen radiographically.

Amputation. Amputation of the arm is occasionally necessary as a life-saving measure in elderly patients, especially in the presence of severe mixed infection.

TUBERCULOUS ARTHRITIS OF THE WRIST

Unlike most other instances of tuberculous joint infection, the wrist is more frequently affected in adults than in children. The disease progresses slowly, little pain is experienced and the joint gradually becomes swollen and rigid. The site of the primary infection is usually the synovial membrane, the radiograph at this stage showing a generalized decalcification of the carpus and the adjoining portions of the metacarpus and the radius (Fig. 65). At a later stage, bone destruction appears in the carpal area, in which it may remain localized or may spread to the *neighbouring bones*.

Swelling usually appears first on the dorsum of the wrist on both sides of the common extensor tendons, and, as a rule, softening and abscess formation follow in the same regions with flexion deformity and partial subluxation of the joint. The tendon sheaths, first on the dorsal aspect, and later on the palmar surface, may become involved in the infection, the development of granulation tissue preventing the movement of the tendons in their sheaths.

FIG. 65.—Tuberculous disease of the Wrist-joint.

Prognosis. Tuberculous infection of the wrist-joint by itself is rarely a fatal disease, but the usefulness of the hand is always greatly diminished by the development of a weak fibrous ankylosis, frequently in a deformed position, and possibly also by the involvement of tendons in the fibrotic mass.

TREATMENT

Complete fixation of the joint in its position of greatest functional advantage for a period of 18–24 months is the essential factor in treatment. This optimum functioning position is 15 degrees dorsiflexion with the hand in line with the forearm. At this angle the wrist should be fixed on a splint which, only in the acute stages of the disease, includes the fingers, care being taken that the metacarpophalangeal and interphalangeal joints remain flexed during the period of immobilization. When the acute stage is passed movement of the fingers should be permitted, the wrist-joint still remaining immobilized at the optimum angle. If sinuses are present, the skeleton hand splint (Fig. 66) is most

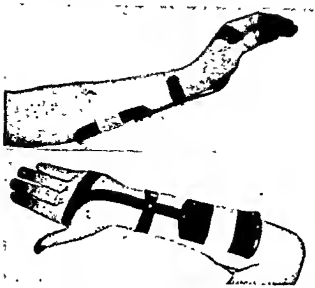


Fig. 66.—Skeleton Hand Splint.

useful, as it allows the necessary dressings to be applied whilst retaining the fixation of the joint.

Plaster-of-Paris casing of the forearm, including the wrist and metacarpophalangeal range of joints, is frequently used with the object of immobilizing the affected area. Although effective in producing fixation, it causes an unnecessary strain by its weight, and by its complete cover of the diseased joint it predisposes to the formation of abscesses, which are seldom seen when splints alone are used.

Operative Treatment

Aspiration or occasionally opening of a tuberculous abscess when necessary must always be carried out under scrupulous surgical cleanliness. As in any other tuberculous joint, drainage is contra-indicated on account of the great danger of sinus formation and mixed infection.

Curettage. This operation is mentioned only to be condemned. When the attempt is made to remove the infected material by scraping, spread rather than cure of the disease is the common result

Excision. The operation of excision of the infected carpus and the adjacent portions of the radius and metacarpus, if carried out efficiently, is such a crippling procedure that it should never be attempted in children and is rarely justifiable in adults.

Arthrodesis. Fusion of the wrist by clearing and freshening of the diseased articular surfaces of the carpus and radius, combined with

the use of a bone graft extending from the radius to the metacarpus, results in stabilizing a weak, painful wrist, but the operation should only be considered when sclerosis of the infected bones is already present, and when the tendons on the anterior and posterior aspects of the joint are working freely.

Amputation. As in the case of disease of the elbow-joint, amputation is performed solely as a life-saving measure, especially when mixed infection is present, and in cases complicated by phthisis or general tuberculous infection.

CHAPTER XI

CHRONIC ARTHRITIS

Many different classifications have been suggested for the various types of sub-acute or chronic arthritis. The multiplicity of the terms, chronic rheumatism, rheumatoid arthritis, osteo-arthritis, infectious arthritis, toxic arthritis, etc., is an indication of the views of the authors as to the probable cause, while at the same time they are an index of the lack of knowledge of the pathological processes leading to these changes.

Chronic arthritis can be divided into two main groups, which cannot always be differentiated, as signs of both conditions may be present in one patient.

1. *Rheumatoid Arthritis*, in which the disease is largely confined to the synovial membrane, perisynovial tissue, and cartilage of the joint.
2. *Osteoarthritis*, in which the pathological changes are seen chiefly in the bony and cartilaginous structures

RHEUMATOID ARTHRITIS

This condition, which is usually of the nature of a polyarthritis, is seen at one of two main age periods.

(*a*) *In Childhood.* The clinical characteristics of this type of the disease were first described by Still. The clinical picture differs, in certain points, from that seen in adult patients The disease is always polyarticular, the joints of the hands and feet being, as a rule, affected first. At the outset there is usually a considerable amount of pain, the affected joints becoming distended with great wasting of the surrounding muscles. As a rule, enlargement of the lymph glands and the spleen becomes obvious at an early stage, while the prognosis in regard to function of the affected joints is poor, the tendency being towards eventual ankylosis (Fig. 67).

FIG. 67.—Advanced Rheumatoid Arthritis in a Child

(*b*) *In the Adult.* The disease occurs almost exclusively in females; the onset is not usually so sudden or so painful, and, although any joint may be affected, the hands and feet are most frequently involved in the initial stages. The metacarpophalangeal and interphalangeal joints become swollen and shiny, with considerable restriction of movement, although this limitation is accompanied by comparatively little pain. Following this involvement the fingers gradually deviate towards the ulnar border of the hand, the displacement occurring at the swollen metacarpophalangeal range. Later any joint may become involved, the knees frequently becoming swollen and flexed with a loss of power of full voluntary or passive extension. The wrists, shoulders, elbows, hips and ankles are also often affected in the same way, deformities appearing owing to unbalanced muscle pull and the action of gravity.

The radiographic appearances at first are those of general decalcification of the bones of the affected joint, while, at a later stage, the joint cavity is diminished and erosion appears at the edge of the bone close to the articular cartilage (Fig. 68).

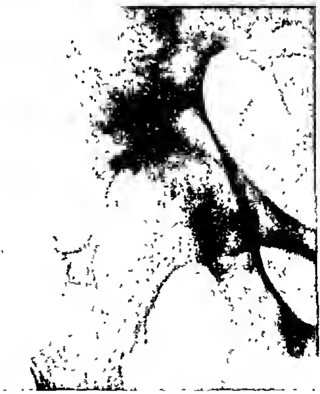


FIG. 68.—Rheumatoid Arthritis of Hip-joint.

The pathological changes consist in round-celled infiltration of the capsule and synovial membrane, the synovial villi proliferate and a layer of vascular fibrous tissue is formed on the surface of the articular cartilages, which may eventually be absorbed and replaced by fibrous tissue.

Differential Diagnosis. This, as a rule, is comparatively simple The slow onset and progress of the disease, the number of joints affected and the periarticular thickening, with the generalized decalcification and loss of joint space, as shown in the radiograph, all point to the correct diagnosis.

Cause of the Disease. It would appear that the disease probably results from long-continued low-grade infection, and that the infecting organism may be of many types and may originate in almost any organ. The disease has been attributed to dental infection, intestinal infection or to septic involvement of any of the sinuses of the body, while the organisms localized from the affected joint, or from the perisynovial tissues, or enlarged lymphatic glands, may be of any type or any strain of virulence. In many cases of rheumatoid arthritis such localized foci of infection can be discovered, but in many others, even the most careful general examination fails to reveal any area of bacterial growth.

Treatment

Before any local treatment is undertaken a very careful general examination must be carried out to discover the possible site of infection. If such an area is found, the sepsis should be dealt with radically if this is possible, or suitable treatment instituted with the object of diminishing the extent and virulence of the process. An autogenous vaccine may be made from the bacteria present, and the use of such vaccine has, in some cases, led to a considerable improvement in the condition of the patient. Unfortunately, in many instances the use of the vaccine has not produced any alteration in the condition of the joints, and in such cases, and in those where it has been impossible to discover the site of infection, other lines of treatment are necessary.

In addition to any specific treatment, the general health should be improved, the prevention of constipation being of the utmost importance, and the diet should be regulated according to the condition of the kidneys and intestinal tract, the basic principles being that it should have a low carbohydrate content.

Numberless drugs have been used in the treatment of rheumatoid arthritis, and each has been widely used and relied on for a period, but prolonged experience of their use has invariably led to disappointment. During the past few years particular attention has been given to the

treatment of rheumatoid arthritis by means of gold salts. Of these there are various compounds, of which the most suitable and least toxic would seem to be Solganol B. Oleosum.

The method of action of the gold salts on the infection is not clear. It would appear that the effect is indirect, causing an improvement in the general body metabolism, and that the drug has no direct effect on the septic processes.

The treatment of the condition by the operation of sympathetic ganglionectomy in the hope of improving an extensive arthritis in the joints of one limb has been tried during the past few years, but the final results obtained have hitherto been unsatisfactory.

Combined with drug or vaccine treatment, improvement in the condition of the affected joint and in its range of active movement can be obtained by the use of radiant heat and gentle massage. The radiant heat should be employed daily for 10–15 minutes, its use over a longer period being followed in many cases by an increase of inflammation and swelling of the joints and a diminution of active movements. Massage should be directed towards improving the condition of the muscles round the joint, and should be combined with gentle passive movements, which should stop as soon as they cause pain to the patient.

From the orthopædic surgeon's viewpoint the chief problem in treatment must be the improvement in joint function. Deformity must be prevented, movements where possible must be encouraged, and, if ankylosis is inevitable, this must be allowed to occur in the best possible functioning angle for the particular joint involved. In dealing with the joints in rheumatoid arthritis there is one outstanding and invariable rule in regard to fixation and movements. Unlike many other diseases where fixation of an inflamed joint leads to a cessation of pain and an increase in movements, in rheumatoid arthritis complete and prolonged immobilization of an affected joint is followed by relief of pain and loss of movements. This rule forms the basic principle for the treatment. Joints which are already deformed may be altered in alignment and yet retain movements, so long as they are not immobilized.

The correction of such deformities must be gradual, movements must be encouraged at the joint whilst its alignment is being altered, and no fixation in plaster of Paris should ever be used, unless the object of treatment is the production of a painless ankylosis at the affected area.

The chief deformities met with in rheumatoid arthritis are flexion of the hip, flexion and subluxation of the knee, adduction deformity of the shoulder, right-angled fixation of the elbow, and flexion and ulnar deviation at the metacarpophalangeal ranges.

Deformities of the lower limbs are best treated by slow correction with weight extension. The weight must be small, and active and

passive movements of the affected joints must be allowed at intervals each day.

Knee-joint. In the case of the knee, where subluxation of the head of the tibia and flexion contracture are usually both present, some difficulty is experienced in straightening the joint without producing further subluxation. In order to avoid this a second line of pull is placed behind the head of the tibia, acting at right angles to the long axis of the bone, so that, as the joint is straightened, the head of the tibia is slowly pulled into its normal alignment.

If a joint is completely disorganized and it is evident that useful function can never follow correction of the position, the affected joint should, if possible, be brought to its most useful angle and allowed to ankylose in that position. This can be carried out simply by correction of the deformity and fixation of the joint in a plaster of Paris casing or suitable splint for a period of 3 months; during the period of fixation the neighbouring joints must be exercised and the general treatment continued.

Arthrodesis. Arthrodesis of an extensively disorganized joint may be necessary, especially where there is great deformity and correction is impossible by traction alone. If the joint can be brought into good alignment operation may often be avoided, provided that fixation of the joint is maintained for a sufficiently long period.

VILLOUS ARTHRITIS

Chronic villous arthritis may be looked upon as the only example of a persistent mon-articular rheumatoid arthritis. It is found only in adult life, the knee being more frequently involved than any other joint, the only predisposing factor being gonococcal infection, a history of which can be elicited in 30 per cent of the patients The pathological changes present in the joint are very similar to those of generalized rheumatoid arthritis. There is the same cellular infiltration of capsule and sheath, the same enlargement of the synovial villi, which often protrude into the joint cavity as large pedunculated masses, but there is not the same tendency to the growth of a fibrous tissue plaque over the surfaces of the articular cartilages, the limitation of flexion of the joint being caused solely by the thickening of the capsule and pericapsular tissues, combined with a small synovial effusion which is usually present in the joint.

Symptoms and Signs. The outstanding features of the condition are the persistent thickening and swelling of the joint which diminish with rest but never entirely disappear, even after long-continued rest in bed. A small amount of fluid can usually be detected in the joint,

but the persistent enlargement is largely caused by the thickening of the synovial membrane and the increase in size of the synovial fringes. On palpation these can be felt as rounded semi-solid masses, which can be moved about through a restricted range. The synovial membrane itself can also be felt through the wasted quadriceps to be definitely thickened and spongy. As a rule, pain is absent, although some aching may be complained of, especially at the end of a day's work, when the knee generally becomes more swollen.

Treatment

Treatment similar to that given for the generalized type of rheumatoid arthritis does not usually have any effect in chronic villous arthritis. If any trace of gonococcal infection can be discovered it should be dealt with effectively, but, as a rule, even when there is a history of previous infection, all traces of it have disappeared. The results of conservative treatment are usually disappointing, even prolonged fixation causing only a temporary improvement. When the disability is great considerable improvement can be obtained by operation.

Operative Treatment. The removal of as much of the infected synovial membrane as is possible without injury to the stability of the joint constitutes the most effective method of dealing with the disease.

Through a vertical incision 6 inches in length at the outer border of the patella, ending below the upper surface of the tibia, the whole of the supra-patellar pouch and the post-patellar pad of fat may be removed. As a rule, removal of the supra-patellar pouch alone is sufficient to ensure a useful joint, and only on rare occasions is it necessary to remove the fatty pad. After suturing the capsule and skin the leg is fixed on a splint at an angle of slight flexion for 2 weeks, during which active movements of the thigh muscles are encouraged. Later, non-weight-bearing exercises of the thigh, combined with gentle massage, rapidly restore the muscular control.

Free use of the joint is permitted after 3 weeks from the time of operation, and the result to be expected is free, painless flexion and extension of the joint from the straight line to at least right-angled flexion. Although this movement following synovectomy is painless, it is usually accompanied by considerable creaking and grating in the joint. The fibrous tissue, which replaces the synovial lining, never becomes as smooth as the original synovial lining, but the creaking, although annoying to the patient, does not interfere with the function of the joint.

OSTEOARTHRITIS

Osteoarthritis, or chronic arthritis, which affects to a greater degree the bony and cartilaginous tissues of the joint, may be either mon-articular or poly-articular.

The pathological changes consist in an irregular growth of bone and cartilage at the edges of the articular surface, and fibrillation and softening of the articular cartilages over their weight-bearing surface (Fig 69)

FIG. 69.—Advanced Osteoarthritis of the Hip-joint

This heaping up of new bone and cartilage at the articular edges advances concurrently with the destruction in the weight-bearing area; eventually the underlying bone may be exposed entirely denuded of its cartilaginous covering. Enlargement of the synovial fringes may be seen as *large pads of synovial covered fat*; the perichondral and periarticular

tissues also become infiltrated, but never to the extent seen in rheumatoid arthritis.

Mon-articular Arthritis. Osteoarthritis, which remains confined to one joint, is invariably the result of trauma. The predisposing trauma may consist of one serious injury, such as would be caused in the hip-joint by a fall on the outer side of the great trochanter, or it may be of slight degree and oft-repeated, as is seen in the osteoarthritis of the metatarsophalangeal joint of the great toe.

With continued use of the affected joint the arthritic changes become more advanced, the osteophytic outgrowths at the edge of the articular margin increase and lead to a steady diminution of the range of movement in the joint. Occasionally these outgrowths from the opposite sides of the joint may approximate so closely as almost entirely to prevent movement at the joint, but true bony ankylosis never occurs, some small amount of active or passive movement always being possible. With increasing limitation of movement pain becomes worse, but in the extreme type, in which there is close apposition of the osteophytic outgrowths, pain may disappear and may be elicited only by forced passive movements.

Osteoarthritis of the Hip-joint

Osteoarthritis of the hip-joint may follow injury to a normal hip-joint in adult life, but it may also follow some alteration to the shape or position of the head of the femur which was present since childhood or adolescence. Thus, such conditions as Legg-Perthe's disease, which causes a flattening and broadening of the articular surface of the head of the femur, or slipping of the upper femoral epiphysis or coxa vara, which result in a change in position of the articular surface, are usually followed in later life by the development of osteoarthritic changes (Fig. 70).

Symptoms and Signs. As a rule, the patient first complains of inability to perform some particular movement, such as passing one leg over the other or tying the shoe. All other movements of the joint at this stage are apparently unaffected, but pain follows each attempt at performing the restricted movement. Gradually the range of movement in the joint diminishes; rotation, abduction and adduction are lost, flexion and extension being retained to a gradually diminishing degree. The thigh becomes adducted, the affected leg becoming apparently shorter, while with increasing pain the patient's activities are restricted.

The radiographic appearances vary with the stage of the disease. At first there may be only very slight osteophytic changes at the articular

margins, but gradually these increase in size until the fully developed osteoarthritic changes are present (Fig. 69).

Treatment

In the treatment of osteoarthritis medicinal measures are even less satisfactory than in rheumatoid arthritis. If there is any discoverable focus of sepsis, this should be dealt with in a radical manner. The use of autogenous vaccine does little to delay the progress of the disease, and intestinal medication has proved to be equally ineffective

Fig 70.—Old Perthes Disease showing arthritic changes

Local treatment of the affected joint by hot packs, hot mud packs, radiant heat, etc., results in a more or less temporary relief of pain, but produces little interruption in the progress of the disease. Electrical treatment by ionization has proved to be of little or no value, and its use is followed in some instances by a considerable increase in the pain and tenderness.

Relief can usually be obtained by mechanical means, which may be summarized as follows:

Manipulation. In the early stages of the disease, when the restriction of movement is limited only in one direction, and the radiograph

shows little or no bony alteration, a considerable improvement in function often follows on manipulation of the joint under anæsthesia.

In this procedure, the patient being anæsthetized, the joint is put once through the full normal range of movement in every direction, and the increased range is maintained by free use of the joint in normal activity. Such improvement of movement is usually accompanied by a disappearance of pain in the joint, and, if the bone changes are minimal, the improvement in function may last from 1 to 3 years.

Plaster Fixation. With a more advanced condition of arthritis, when definite bony outgrowths are already visible, manipulation is contra-indicated, and, if attempted, is usually followed by increased pain and diminution of movement.

At this stage any pain present in the joint can be relieved by fixation of the hip in a plaster spica for 3–6 months. The spica holds the hip-joint at rest but does not restrict movement at the knee-joint, and the patient is enabled to carry on most of the normal activities. As a result of this prolonged fixation the range of movement is not diminished but is often increased, and this improvement may last for several years.

If the fixation in plaster has relieved the condition of the joint, after removal of the plaster case a canvas or leather hip-shield should be worn for another 6–12 months. This type of shield, although not so effective in immobilizing the joint, limits the range of movement and prevents to some degree the return of pain. Freedom from all fixation should be given slowly, a flannel spica bandage being worn as a support for another year.

Operative Treatment

When the disease is more extensive and osteoarthritic changes are present on the head of the femur and on the acetabulum, neither manipulation nor fixation in plaster can produce any permanent improvement, and more radical procedures are necessary. There are certain possible lines on which this operative treatment may be based, and each of these methods has been used sufficiently long to enable a judgment to be arrived at as to its relative usefulness.

1. Arthroplasty.
2. Arthrodesis.
3. Reconstruction Operation.
4. Pseudarthrosis.
5. Osteotomy.

1. Arthroplasty. The operation of arthroplasty, or the formation of a new functioning joint in the place of one which is limited in movement and painful, is the ideal which has been sought for by generations of surgeons.

The technique which has been employed is the wide opening of the joint, the removal of the articular cartilage of the head of the femur, and the acetabulum, the remodelling of the head of the femur to fit comfortably into the acetabulum, and the interposition of some tissue between the roughened bones to prevent their fusion. Fascia lata was commonly used as the intervening membrane, but unfortunately the results of the operation were usually unsatisfactory, pain and limitation of movement persisted and the method fell into disuse.

The technique of Smith-Petersen in performing arthroplasty of the hip is almost identical with that described, with the important difference that after remodelling the head and the acetabulum, a vitallium metal cup is placed between the head and the acetabulum. The remodelling of the bones is done widely in order that the diminished head and neck of the femur may move freely within the metal cup, which in its turn moves freely within the enlarged acetabulum. The essential point of the technique of a successful operation is the meticulous care with which the joint is approached, the muscles attached to the ilium being gently freed, and the capsular tissue being widely removed before closure of the wound.

Some of the results given by the method are excellent, but in some instances further operative procedures are necessary because of a recurrence of pain and a reappearance of the restriction in the joint movements.

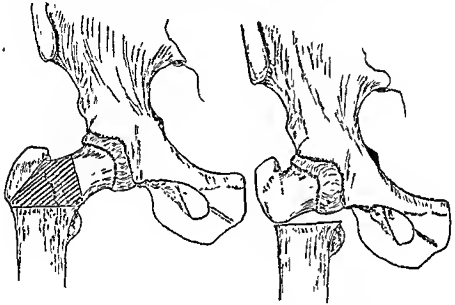
2. Arthrodesis. By arthrodesis of the joint the pain, which is the result of movement of the roughened bony surface, disappears and the patient can bear weight on the hip without discomfort. Unfortunately the loss of all movement in the hip-joint of a patient of middle age or later life leads to greatly increased strain on the lumbar spine, which, in many cases, is also affected by osteoarthritic changes The immediate after-result of a successful arthrodesis is invariably good, but after a period, which may vary between 2 and 8 years, the patient usually returns complaining of increased pain and disability in the lumbar spine This objection is not applicable where the osteoarthritis has developed in a young patient as a result of change in the shape of the head of the femur, caused by a pre-existing Perthe's disease, or a severe direct injury. In these patients when the other joints are normal the restriction of movement, which follows arthrodesis of the hip, can be masked by the increased range which develops in the lumbar spine.

The method of performing the operation of arthrodesis has already been described in Chapter VII.

3. Reconstruction Operation of Whitman. The reconstruction operation of Whitman is based on somewhat similar lines to that of arthroplasty. After removal of the enlarged femoral head, the apex of the neck of the femur is smoothed and placed in the acetabulum.

In order to retain it in this position the great trochanter, with its attached muscles, is cut off and reattached farther down the shaft of the femur so as to give control and better leverage. The leg is now placed in abduction, enabling the remnant of the neck to remain in the acetabulum. The objection to the operation must always be the presence of a small femoral segment in a large acetabular cavity, an arrangement which is frequently followed by an increase of the arthritis.

4. **Pseudarthrosis.** The provision of a movable joint, even though it is not normal in strength, is always advisable in the case of osteoarthritic infection of both hip-joints, especially when the lumbar spine



(a) (b)

FIGS. 71a and b.—Jones's Pseudarthrosis of Hip-joint.

is also affected by arthritis, and is limited in its range of movement. Following such an operation the disability is lessened, and the patient is more capable of carrying on his normal functions.

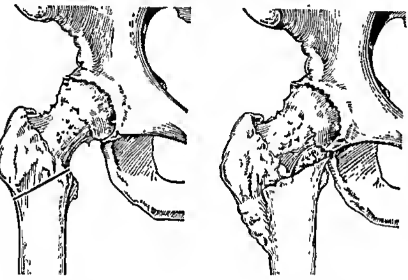
The most efficient technique of pseudarthrosis is that described by Jones. Through a curved incision on the outer side of the hip, the great trochanter is detached from the femur and is turned up with its attached muscles. The neck of the femur is now divided close to the head, and the shaft cut through just above the lesser trochanter. The portion of bone between these two incisions is now removed, and the trochanter is then turned in and sutured to the remaining portion of the head and neck (Figs. 71a and b). Directly after the operation, extensions are applied to the leg, which should be pulled into extreme abduction so

that the upper end of the femoral shaft may lie below the transplanted great trochanter.

Movements, both active and passive, should be commenced after the first fortnight. With the resumption of walking the stability of the limb is greatly improved by the wearing of a caliper for at least 12 months.

The result is good so far as movement is concerned, a range of 90 degrees flexion being the average result, but the stability of the limb is lessened, a disadvantage which is outweighed by the great functional improvement produced by movement.

5. Osteotomy. The simplest of all the possible operative measures,



(a) (b)

Fig 72a —Oblique osteotomy showing site of osteotomy 72b —Showing position of fragments after successful oblique osteotomy

and the one which causes the least shock to elderly patients, is the operation of oblique osteotomy of the femur. The line of weight-bearing in the limb and the site of pressure on the diseased articular surface can be altered by means of an oblique osteotomy of the femoral shaft. This is carried out through a 5-inch incision on the outer aspect of the upper end of the femur. The line of division of the bone passes from below upwards and inwards at such a level that the upper end of the osteotomy lies at the level of the lower border of the head of the femur, a point which is usually, although not always, above the lesser trochanter After the division of the bone the upper end of the shaft is pushed inwards until it lies close to the lower border of the acetabulum (Figs. 72*a* and 72*b*),

and is retained there by fixing the hip, thigh and leg in a long plaster-of-Paris spica for 3 months.

Following the osteotomy, the first temporary plaster is applied for 3 weeks with the thigh flexed to an angle of 30 degrees and the limb abducted to an equal amount. This fixation of the limb in a position of flexion and abduction for the first few weeks is an essential point in the operation, preventing the tendency of the upper end of the femoral shaft to displace forwards. When the plaster is changed and the stitches

FIG. 73.—End result of successful oblique osteotomy

removed at the end of 3 weeks the limb is brought to the neutral position, and fixed there in a spica in which the knee is bent for a period of 3 months.

Certain conditions are necessary before this procedure can be used. The hip must not be fixed in extreme flexion, and if such a deformity is present, the operation must be postponed until the flexion has been corrected, either by manipulation, traction or transtrochanteric osteotomy. Secondly, there must be sufficient movement at the hip-joint to allow adduction of the upper fragment to occur following the operation. The essential part of the operation consists in the transference

of the shaft of the femur into the exact position below the acetabular margin, and the second factor, which is equally important, is union of the two fragments of the femur (Fig. 73). If non-union occurs at the site of the osteotomy the result is a weak, painful hip, a condition which is more disabling than the original osteoarthritis, but this tragedy is prevented by fixation of the *hip for 3 months*.

No splint or support is usually required after the removal of the plaster case, and the patient can walk about with comfort and relief within a few weeks, although the improvement, as a rule, continues for several months.

Osteoarthritis of the Knee-joint

Osteoarthritis of the knee may be present as a unilateral or bilateral condition. When unilateral, the condition is invariably the result of trauma, which may have been either one severe injury or repeated slight traumata, such as result from the continual slipping and locking of a loose semilunar cartilage. The bilateral condition is seen in both sexes, occurring in women usually about the menopause, and in men at a later age.

Signs and Symptoms. The knee is usually thickened with considerable muscle atrophy above and below the joint. Full extension of the joint is generally impossible, and on palpation movements are accompanied by a harsh grating, especially under the patella and ligamentum patellæ. Synovitis may be present but is usually *slight* in degree, while the radiograph (Fig. 74) shows sharp bony outgrowths at the articular margins of the femur and tibia, and, in the lateral view, at the upper and lower edges of the articular surface of the patella. The patient often complains of pain in front of the joint under the ligamentum patellæ, and may also complain of pain along the line of the articular surface of the tibia. Frequently, as a result of a twist of the joint, pain is complained of along the line of the internal cartilage, and unfortunately a mistaken diagnosis of derangement of the cartilage is of common occurrence. In a severe degree of osteoarthritis the knee is flexed to 20 degrees or even 40 degrees. Flexion is possible to beyond a right angle, but extension of the joint is impossible owing to the mass of bony outgrowths round the articular margins.

Treatment

General treatment, as *described for osteoarthritis, should* be instigated in an attempt to eradicate any persistent sepsis. Locally, the thickened and tender portions of the lining membrane of the joint and the enlarged post-patellar pad should be relieved from repeated injury by preventing full extension of the joint in walking. *With the roughened articular*

surfaces of the femur, tibia and patella, full extension of the joint leads to nipping of the post-patellar pad. This results in effusion into the pad, which becomes thickened and more likely to be nipped again. Relief from this nipping is provided by raising the heel of the shoe at least three-quarters of an inch so that the knee remains slighty flexed in walking. With relief from injury the thickening of the post-patellar pad gradually diminishes, and further painless extension of the joint is

FIG. 74.—Osteoarthritis of Knee-joint.

possible. In addition to raising the heel of the shoe, the knee should be protected by a large horse-shoe pad of felt and flannel bandage, which support the joint and at the same time protect it from cold.

With very extensive osteoarthritis of the knee which is causing great pain and disability, arthrodesis of the joint is often necessary and may be the only method by which the function of the limb can be restored.

Occasionally, when the arthritic changes are almost entirely confined to the patello-femoral articulation, removal of the patella is followed by considerable improvement in function, but the operation is one

which should be undertaken only after very careful consideration of the conditions present.

Loose Bodies in an Osteoarthritic Knee

Occasionally, portions of cartilage or cartilage and bone are broken off from the articular surfaces or from the articular margins and remain loose in the joint, causing symptoms of locking at different areas. The presence of such a loose body is likely to cause an increase in the osteoarthritic condition and, if recognized, it should be removed by operation, the patient being informed that such removal will delay further destruction of the joint, but cannot cure the condition of arthritis already present.

Osteoarthritis of Other Joints

Osteoarthritis of the spine is considered in Chapter XIII, while osteoarthritic changes in other joints are dealt with on the lines already indicated.

NEUROPATHIC ARTHRITIS

Charcot's Joints

This condition, which was previously considered as being invariably due to a previously acquired syphilitic affection, is now recognized as occurring in syringomyelia, myelitis, involving paraplegia and peripheral nerve lesions. As a rule, one of the larger joints is affected, the knee, ankle, shoulder, hip or intervertebral joints all being affected by disease on occasion

Clinical History. The onset of the disease may be gradual but, as a rule, the patient notices that the affected joint becomes distended with fluid, the occurrence being characteristically painless. The swelling remains for a few weeks and gradually subsides, leaving the joint abnormally lax with excessive movements in all directions. One or more other joints may become similarly involved, while occasionally no further sign of the disease appears, the patient apparently being cured.

The outstanding clinical feature of the disease is the entire absence of pain at any stage, even in the presence of great swelling or the excessive creaking and grating which are always present when the joint is moved. This feature is usually sufficient to distinguish the disease from other forms of arthritis.

Radiographic Appearances. The articular surfaces are destroyed, and in many areas extensively absorbed, while at the edges of the articular margins and on the joint capsule flakes of new bone are deposited (Fig. 75).

Pathological Changes. Widespread destruction of the articular cartilages and of the underlying bone occurs with eburnation and round-celled infiltration of all the ligaments and capsule of the joint. The synovial membrane is covered on its inner aspect by an incomplete layer of fibro-cartilaginous tissue, presenting villous processes and polypoid masses. This pannus often extends over the bone ends.

FIG. 75.—Charcot's disease of the Knee-joint, showing loss of outline and new bone formation.

Treatment

Anti-syphilitic measures have no effect on the progress of Charcot's disease once it has developed. Locally, support of the affected joint by plaster or splints helps in reducing the fluid present, and enables the patient to use the limb. In a young patient operation to stabilize the flail joint is justified, although the chances of success are comparatively slight. Occasionally, with extreme destruction of an ankle-joint, amputation is advisable.

CHAPTER XII

EPIPHYSEAL AFFECTIONS

OSTEOCHONDRITIS DEFORMANS JUVENALIS, PSEUDO-COXALGIA OR LEGG-PERTHE'S DISEASE'

An affection of the hip-joint of which the first clinical signs appear usually between 5 and 10 years of age, occurring more commonly in males than in females The various titles which have been given to the condition indicate the ideas of their originators as to the cause of the disability.

ETIOLOGY

Although numerous suggestions have been advanced as to its etiology, nothing definite is known, two main theories being held in regard to its causation:

1. Traumatic.
2. Infective.

Traumatic. Legg, who originally described the condition, first suggested that all the bone changes could be explained on the theory that the condition was the result of trauma to the cervical region of the femur. Following an injury not sufficiently severe to produce a fracture, the blood supply to the upper femoral epiphysis was obstructed and diminished, whilst that to the remainder of the neck of the femur was increased, leading to a disintegration of the epiphysis and a concurrent hypertrophy of the cervix femoris

Infective. The second theory, that alterations in the bone result from mild septic infection of the neck of the femur, is supported by several authorities, and the basis on which this theory rests is the discovery by Perthe, Kidner and others that from bony tissues removed from the affected area organisms have been grown of which the most common was the staphylococcus aureus. Again, pathological examination of the tissue so removed had disclosed that the bone changes were such as might be expected to result from septic infection rather than from trauma. It is difficult to decide as to the relative truth of these two theories, but the fact that the disability frequently follows on the reduction of a congenital dislocation of the hip, especially where excessive trauma has been employed, and that no instance of osteomyelitis complicating pseudo-coxalgia has been reported, would suggest that the traumatic theory has more foundation for its support.

Clinical Features

As a rule, the first noticeable sign of the disability is the occurrence of an intermittent limp, which usually appears after exercise and disappears following rest. The limp may be noticed at any age between 2 and 18 years, but, as a rule, it first becomes evident between 5 and 10 years of age. At first it appears to be very slight and may give rise to little concern on the part of the parents, but gradually the limp increases and becomes so noticeable that advice is sought.

Fig. 76.—Bilateral Perthe's disease, showing mushroom type in one hip, cap type in other

On examination of the child it is found that the leg on the affected side is either equal in length or not more than one-quarter to half an inch shorter than the other. The great trochanter is slightly more prominent than on the normal side, and the thigh is usually held in very slight abduction. When the active and passive movements at the hip-joint are examined it is found that, while flexion and extension are normal in range or restricted to a minimal degree, abduction, adduction and rotation are considerably diminished.

Radiographic Appearances. Definite radiographic changes are usually apparent as soon as the first signs of limping have drawn attention to the condition. The upper epiphysis of the femur appears, either

as a small pointed cap perched on the end of the neck of the femur or as a broad fragmented and flattened cover over the metaphysis (Fig. 76). The neck of the femur itself is considerably thickened, and definite cystic spaces can occasionally be distinguished in its substance. The upper border of the acetabulum may also be somewhat fragmented and may show similar cystic cavities. The joint space between the femur and the acetabulum remains normal in size and does not show the narrowing which is indicative of a true arthritis.

Differential Diagnosis

Tuberculous Arthritis. Before Legg's description of the condition, osteochondritis juvenalis was considered to be a mild type of tuberculous arthritis and was treated as such. The differential diagnosis as between these two conditions is, as a rule, comparatively easy; the free flexion and extension and the radiographic changes, combined with the presence of a normal joint space, indicate the true nature of the disability. Occasionally, some difficulty may be encountered in the diagnosis of tuberculous osteitis of the neck of the femur, where the changes may be curiously similar to those of osteochondritis, and where the restriction of movements may be of a somewhat similar type. Here the differentiation depends on the presence of the fragmentation of the epiphysis, which is always present with osteochondritis juvenalis and never in the case of tuberculous osteitis.

Prognosis

Even without treatment, considerable improvement may occur in the condition of the head and neck of the femur, and occasionally the restoration of the architecture of the bone may even be complete. As a rule, however, if efficient treatment is not employed the neck of the femur remains thickened and the head enlarged with an irregular, rough outline which predisposes to the development of osteoarthritic changes in later life.

Treatment

In the early stages, when the bone changes are progressing, as evidenced by the presence of protective muscle spasm round the joint, definite improvement usually follows on relief of the inflamed tissues from weight-bearing. Prolonged immobilization of the joint is not necessary, and movements without weight-bearing may be safely allowed as soon as muscle spasm has disappeared. The routine to be followed is simple, extension is applied to the limb until any deformity already present has been corrected, and this fixation is maintained for 4–8 weeks until periarticular muscle spasm has disappeared. Free movements of the joint in bed without weight-bearing are then permitted for at least

FIG. 77a.—Legg Perthe's Disease at the onset of treatment

6 months. Subsequently the child is allowed to walk without any form of protection, the only proviso being that, on any complaint of aching or tiredness in the hip, rest should be resorted to immediately.

The improvement in the shape of the femoral head and the acetabular cavity depends largely on the period of rest given to the affected tissues. The longer this period the greater the improvement. Danforth has

FIG. 77b.—Same patient 5 years later.

suggested that this period of relief from weight-bearing should extend over 5 years, an ideal which cannot often be attained for economic reasons. The results obtained by this form of treatment are, on the whole, excellent. In many instances the deformity of the femur disappears, leaving an apparently normal joint, whilst in the others improvement is the rule (Figs. 77*a* and 77*b*).

During adolescence when the signs of irritation have disappeared the patient feels no disability and complains of no pain, although occasionally aching in the hip is present in those patients in whom there is still considerable bony deformity. This period of relief usually lasts until the patient is between 30 and 50 years old when the repeated irritation of the acetabular cavity by the irregularly shaped femoral head leads to the development of osteoarthritic changes (Fig. 70), the treatment of which is described in Chapter XI.

EPIPHYSITIS OF THE TIBIAL TUBERCLE, OSGOOD-SCHLATTER DISEASE

This disability, which was first described by Osgood, consists in injury and, in some cases, fragmentation of the epiphysis of the tibial tubercle, accompanied by pain, tenderness and occasionally swelling over the site. The condition occurs more frequently in boys than in girls, and may be bilateral but, as a rule, it is confined to one leg.

The symptoms and signs, which are localized to the region of the injured area, consist of pain and tenderness on pressure over the site of the tubercle. The pain follows on active use of the limb, disappearing with rest and reappearing with exercise, especially with such games as football. The tenderness remains until the inflammatory changes disappear.

Radiographic Changes. These are not often distinctive, and the diagnosis can rarely be made on them alone. There may be some elevation of the tubercle from the surface of the tibia, and in a few instances definite fragmentation of the epiphysis is also present, the decision as to the presence of abnormal changes in the epiphysis being based on a comparison of the radiograph of the affected limb with that of the normal side.

Treatment

In the very acute stage, with swelling, tenderness and pain over the tibial tubercle, complete rest should be given to the joint by the use of a straight posterior splint at the back of the knee for 2–3 weeks. When the acute signs have disappeared more and more freedom may be permitted, the tender area being supported by a circular strap applied over that area and round the leg at this level. Heat, by radiation or

hot packs, helps to reduce the inflammation, and gentle massage of the area often relieves the tissues.

Occasionally the tenderness and swelling of the affected area persist, in spite of every form of conservative treatment, and, if the discomfort is extreme, relief can be obtained by opening or drilling the tubercle and the underlying diaphysis. Through a small lateral incision a drill or a narrow chisel is driven through the tubercle into the tibia below, no fixation is necessary and the relief of pain is usually rapid.

APOPHYSITIS OF THE OS CALCIS

Inflammation and irritation of the epiphysis on the posterior aspect of the os calcis is often seen in children, especially in boys between 8 and 14 years of age. The changes consist in swelling, tenderness and apparent enlargement of the epiphysis, the clinical and radiographic signs being almost identical with those found in Osgood-Schlatter disease of the tibial tubercle (Fig. 78). The cause of the two disabilities would

FIG. 78.—Old Apophysitis of Os Calcis

appear to be similar, being the result of excessive strain on the epiphysis by the powerful muscle masses which are inserted into those areas.

The symptoms and signs of the condition consist in pain, tenderness and swelling over the affected area, the severity of the symptoms being definitely increased by games or active physical exercises.

TREATMENT

Pain and tenderness are both relieved if the heel of the shoe is raised $\frac{1}{4}$ to $\frac{3}{4}$ of an inch. The relief is still greater if the stiffening is removed from the posterior part of the upper of the shoe. By this simple procedure the tension on the epiphysis is reduced owing to the relaxation of the calf muscles, and the tenderness gradually disappears in the course of 2–3 months. The final result depends on the length of time between

the onset of the inflammatory changes and the commencement of treatment. If this interval is short, restoration to normal is to be expected, but where bony enlargement is already present, the pressure of the back of the shoe may produce a bursal swelling at a later date. These bursæ form usually between the skin and the tendo achillis, but may occasionally be present between the tendon and the bone. Relief from pressure can be obtained by removing the stiffening from the back of the shoe, but if the swelling is large it may be necessary to remove it together with a portion of the enlarged bone.

Through a lateral incision on the outer side of the tendo achillis the bursa is dissected from its connections, and after retracting the tendon, the upper enlarged portion of the os calcis should be removed by a sharp chisel. The after-treatment is similar to that employed in treating the acutely inflamed bursa, namely, rest, followed by a temporary raising of the heel of the shoe.

COXA VARA

In a normal adult the angle between the shaft and the neck of the femur is 125–130 degrees. In children the angle is usually considerably greater, and may be 150–160 degrees, any considerable decrease of this angle constitutes a deformity which is described as coxa vara. The alteration in the angle may be slight, or may be so great that the head and lower border of the neck of the femur lie along the inner aspect of the shaft. Combined with this alteration of the angle, there is also in this deformity a definite twisting backwards of the femoral neck, so that the mechanics of the joint are interfered with in two planes

TYPES OF COXA VARA

Congenital. A typical coxa vara deformity of the neck of the femur may occasionally be discovered as a congenital deformity without any other obvious bony abnormality being present, but, as a rule, a coxa vara deformity of this type is associated with congenital dislocation of the hip-joint, or with some other mal-development of the pelvis.

Acquired Coxa Vara—Bone Softening. Any general or local disease of bone which results in softening or weakening of the femoral neck usually leads to the appearance of a coxa vara deformity through the action of body-weight. The most common of these generalized bone diseases is undoubtedly rickets, which is also the most frequent cause of coxa vara deformity in children (Fig 79) Changes of a similar type in the angle of the bone are also seen in the rarer bone diseases, such as osteomalacia or osteitis fibrosa, in which the angle gradually diminishes and the typical deformity appears

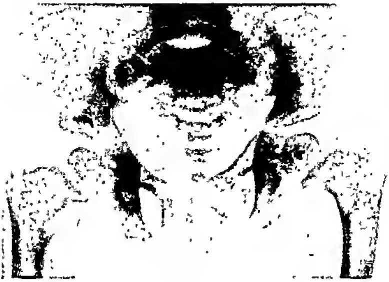


FIG 79.—Rachitic Coxa Vara.

Fractures of the Neck of the Femur. Alterations in the normal alignment of the upper portion of the femur may also follow on fractures in the region of the femoral neck; here, as a result of imperfect alignment, union of the fracture may take place in a position of coxa vara. In children this is especially noticeable where fractures in this region are often of the greenstick variety, incomplete reduction of the fracture is the rule rather than the exception, and the deformity of coxa vara frequently persists.

Slipped Femoral Epiphysis. Slipping upwards of the neck of the femur on the head at the level of the epiphyseal cartilage is a comparatively common displacement, and is usually seen in children between 7 and 14 years of age. Following some injury, which may be comparatively slight, the neck of the femur slides upwards and forwards so that the head is forced into the postero-inferior area of the acetabulum; such a displacement may be unilateral or bilateral. In the unilateral type the patient is apparently healthy and normal in size for his years, and the history of injury given is usually such as would indicate a severe transmitted injury to the joint—the most common story being of a jump from a height. The radiograph shows the displacement upwards of the neck of the femur with apparent displacement downwards of the head (Fig. 80).

In the bilateral type the patient shows the typical Frölich syndrome, being excessively fat with evidence of disturbance of some of the internal

Fig. 80.—Slipping at the upper epiphyseal line of the Femur.

secretory glandular functions Thus, in boys, undescended testes may often be found in association with the displacement. In this type of patient the lesion usually occurs first on one side, and later the other hip shows the same displacement without any history of accident. In addition to the displacement the radiograph usually shows extensive decalcification of the neck of the femur, especially at its inner inferior margin. Although some slight injury may have been the determining cause of the displacement, a predisposing factor was already present in the pre-existing softening of the neck of the femur.

Infantile Type. A separate and distinct type of coxa vara has been described by Fairbank as the infantile type of coxa vara, although the condition should probably be included amongst the true congenital deformities Figs. 81*a* and 81*b* illustrate this infantile type, which is characterized by the presence of a small triangular wedge of bone in the lower border of the neck of the femur, separated by a distinct gap from the remainder of the neck of the femur. The origin of this separate bony mass has been discussed, and suggestions have been made that the separation is the result of a fracture, but the frequent occurrence of the condition as an equal bilateral deformity rules out this suggestion.

FIG. 81a.—Infantile Coxa Vara, showing typical triangular piece of bone in inferior border of neck

FIG. 81b.—Infantile Coxa Vara after Transtrochanteric Osteotomy

It is probable that this triangular mass is developed from a separate ossific centre. As the child grows the line of separation between the neck of the femur and the triangular mass gradually disappears, with bony fusion between the separated portions of the neck and with the persistence of the coxa vara deformity.

Signs and Symptoms of Coxa Vara

With the alteration in the angle of the neck of the femur the great trochanter is raised above Nelaton's line to a degree corresponding with the severity of the deformity. In a unilateral deformity the affected leg is shorter than the normal, and the range of movement in the hip is restricted in certain directions. Thus, abduction is diminished or even lost in a severe deformity, whilst the range of internal rotation is definitely decreased. At the same time the movements of adduction and external rotation at the joint are normal or slightly increased.

Differential Diagnosis

This usually presents little difficulty; occasionally there may be some doubt as to the differentiation of this deformity from congenital dislocation of the hip, but the absence of telescoping and the appreciation of the presence of the femoral head in the acetabulum is sufficient to distinguish the two conditions.

Treatment

Treatment naturally depends on the cause of the deformity. In the presence of active rachitic changes, rest in bed and anti-rachitic treatment result in a slow but steady increase in the angle and, as a rule, in this type of coxa vara no operative correction is necessary.

The treatment of slipping femoral neck, or slipping femoral epiphysis as it is more commonly called, depends on the length of time which has elapsed between the displacement and the commencement of treatment. In the acute case in which the lesion has been discovered soon after its occurrence, continuous, prolonged extension on the affected limb usually results in a rapid restoration of the normal position without any subsequent interference with the movements of the hip-joint At this stage, restoration of the exact anatomical position can also be effected under anæsthesia by traction, abduction and internal rotation of the leg—the manipulation advised by Whitman for reduction of a fracture of the neck of the femur. This method, whilst effective in restoring the normal anatomical alignment of the femoral neck, is often followed by a limitation of movement in the joint with irregularity of the head of the femur.

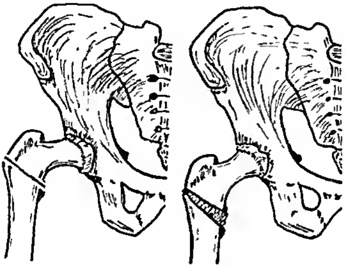
As the interval between the occurrence of displacement and the commencement of treatment lengthens, the difficulty of reduction increases until such replacement is only possible by osteotomy of the neck of the femur through the united line of displacement. Although such a procedure may give an anatomically correct reduction of the deformity the clinical result is unsatisfactory. Owing to the interference with the blood supply to the head of the femur, non-union of the fracture or partial ankylosis of the hip-joint commonly result, and the operation cannot be advised. When the displacement is of long standing the upper border of the neck is convex in outline and the lower border definitely concave. A transverse bony ridge is usually present on the upper border of the neck, representing the upper and inner margin of the displaced femoral neck. Operative removal of this bony ridge, although possible, is followed by an increased limitation of movement and considerable pain, and, although the procedure may be successful as far as the radiographic appearances go, the clinical result is always unsatisfactory.

At this stage, in the presence of the transverse ridge, improvement in function can only follow on osteotomy of the femur, of the type used in the treatment of any coxa vara, by which the angle of the neck is altered and the alignment of the femur restored to normal

Before performing an osteotomy of the upper part of the femur for the correction of coxa vara deformity, the surgeon must make sure that adduction of the hip is free, because, if this movement is restricted

or lost, the hip will remain fixed after operation in extreme abduction. When free adduction is possible the deformity can, to a large extent, be corrected either by a simple transtrochanteric osteotomy, or by the removal of a wedge of bone from the outer aspect of the femur.

1. Transtrochanteric Osteotomy in which the femur is divided from above downwards and inwards through the regions of the trochanters (Fig. 82). After division of the bone the limb is abducted so that a



(a) (b)

FIG. 82.—Drawing of Transtrochanteric Osteotomy.

(a) Site of Osteotomy. (b) Position of femur after abduction, new bone forming in gap.

gap is left in the line of the osteotomy at its lower end. Traction is continued uninterruptedly at this angle, the patient being retained during the correction on a frame, the angle of abduction being judged according to the degree of the deformity. Fixation is continued until the gap in the femur fills up with new solid bone. Subsequent treatment consists in non-weight-bearing exercises for 2–3 months, followed by free use of the limb.

2. Wedge Osteotomy. In this procedure a small wedge of bone, with the base outwards, is taken from the region of the base of the trochanters. By abduction of the thigh the wedge is now closed so that the angle between the neck and the shaft of the femur is altered. The hip is then fixed in a plaster-of-Paris case in full abduction until the osteotomy has joined, when walking may be permitted without support.

KIENBOCK'S DISEASE OR OSTEOPOROSIS OF THE CARPAL SEMILUNAR

The occurrence of the osteoporosis and fragmentation, which is characteristic of Kienbock's disease, affects not only the carpal semilunar but is occasionally seen in the other carpal bones, especially the scaphoid and the trapezium. Trauma, of a mild type, would appear to be the exciting cause, a severe strain of the wrist is followed by pain, which rapidly diminishes but reappears after a quiet interval of one or two months. The radiograph taken at the time of injury shows no abnormality, but later shows a narrowing, and in some cases a fragmentation of the semilunar with extensive osteoporosis of its substance. With continued use of the joint pain persists and increases, while swelling and synovitis of the joint are evidenced by the disappearance of the normal hollows on the back of the wrist If the condition is ignored arthritic changes appear on the edge of the scaphoid and of the neighbouring articular surface of the radius, with an increasing limitation in all the movements of the joint and with persistent pain

The diagnosis is made by the recognition of the localized area of osteoporosis, and by the presence of normal interosseous spaces between the semilunar and its articulating bones.

Treatment

Conservative. The most satisfactory type of treatment for the condition is prolonged immobilization. The wrist is fixed in a plaster case in slight dorsiflexion for at least 3–6 months, or until the radiographic appearances indicate a recalcification of the affected bone.

Operative. *If this form of treatment is to be employed it should* be given a fair trial. As a rule, removal of the affected bone is undertaken only in those patients who have not done well under prolonged conservative treatment, and in whom arthritic changes are already present. *Removal of the bone, if it is to be employed*, must be done early and completely. The affected bone must not be levered out of its bed, but should be removed by dissection without trauma

Following the removal of the bone the wrist must be immobilized *for at least 4 weeks*, and for a further period of 2 months heavy manual labour should be avoided. If the affected bone is removed before arthritic changes have appeared in the joint, the function is good, but removal in the presence of *arthritis does not improve the condition of the wrist or its function*

Arthrodesis of the Wrist. In the later stages, when a painful arthritis is already present, and any movement of the joint is extremely painful, stabilization of the wrist by arthrodesis improves the power of grip *and enables* the patient to resume heavy manual labour.

CHAPTER XIII

NON-TUBERCULOUS AFFECTIONS OF THE SPINE

KYPHOSIS

At birth, and for the first 6 months, the spine of the normal recumbent child appears as a straight line from the occiput to the sacrum. Later, when the child is held in the sitting position, the alignment is altered, a long gentle posterior curve being developed from the occiput to the sacrum. Still later, this posterior curve disappears in the cervical and lumbar regions, so that in time, with the assumption of the erect position, the normal anterior curves are present in the cervical and lumbar regions with a posterior curve in the dorsal area. Any considerable increase in the normal posterior convexity of the thoracic spine is defined as kyphosis, whilst an increase in the anterior lumbar curve is described as lordosis.

The vertebral border of each scapula lies parallel to, and about $1\frac{1}{2}$–$2\frac{1}{2}$ inches from, the spinous processes of the vertebræ. In this position the scapulæ help to fill the space on each side of the spine, producing the normal flat appearance of the back. The scapulæ are retained in close proximity to the spine solely through the action of their muscle attachments, and, if this muscular control be defective, the scapulæ tend to fall forward and downward, leaving the thoracic spine convex both posteriorly and laterally, a condition which is described as round back, or round shoulders.

ROUND BACK

This condition is seen in its most typical forms in children of abnormally low muscular development, or in otherwise normal children after a severe debilitating illness followed by loss of muscle tone. As the shoulders fall, not only forward but also downward, the apparent length of the neck is greatly increased. The head is pushed forward from the upper dorsal vertebræ, leaving the spinous processes of the lower cervical and upper dorsal vertebræ unduly prominent. Accompanying this projection of the head and increased kyphosis of the dorsal spine, there is a considerable increase in the lumbar lordosis, although occasionally the spine retains its infantile appearance of a single posterior curve extending from the occiput to the sacrum. In the early stages of the deformity the movements of the spine are normal, the abnormal prominence of the thoracic region disappearing on recumbency or on strong muscular effort, but if the deformity is of long standing, mobility is often lost and complete correction becomes impossible. This rigidity, which is at first caused solely by the ligamentous and muscular con-

tractions, may later become a true bony deformity owing to secondary wedging of the anterior aspects of the affected vertebræ.

Symptoms and Signs

These children are almost invariably overgrown with weak muscular development. They are usually flat-footed, walking with the feet widely everted, and with a prominent abdomen The head projects forwards and downwards, and life is often a burden to them on account of constant parental commands to stand straight, which simple act is, for the more advanced type, an impossibility. They are noticed to be extremely clumsy in all their movements and are particularly poor at games or gymnastic exercises. One of their most obvious characteristics is their lethargic and even dull outlook, from which they readily recover with improvement of the spinal deformity. In most cases the condition is entirely painless, and advice is sought solely on account of the deformity, but occasionally the child complains of slight aching in the lumbar spine and over the back of both hips and thighs Sometimes also aching is complained of in the feet and legs, probably the result of the constant strain on the ligaments and muscles of the legs caused by the abducted and everted position of the feet.

Differential Diagnosis

This usually gives little difficulty; the clinical appearance of a long, gradual type of kyphos, freely movable in every direction, with normal radiographic appearances and without pain, eliminates all the more serious types of spinal involvement.

Treatment

If efficient treatment is started at an early stage before the deformity has become fixed, correction is comparatively easy. Obvious errors of posture, such as the habit of sitting with the shoulders hunched over lessons, must be corrected. Suitable clothing must be worn, and this must be so designed that it does not drag unduly on the shoulders or prevent full expansion of the chest. Errors of sight, which might lead to the adoption of an unsatisfactory position while reading, must be dealt with by suitable glasses. In addition, light muscular exercises, such as the movements of swimming which can be easily carried out on the floor, must be started immediately and continued until correction is complete and the child can hold the spine straight without undue effort. In addition to the ordinary exercises, great stress must be placed on deep breathing, which should be carried out in the recumbent position. If rigidity has already developed, treatment should consist of recumbency, combined with the use of a small hard pillow between the shoulders and the floor, thus tending to produce the maximum correction of the

deformity. In prescribing exercises the surgeon must remember that the weak musculature of such a child can only be improved by exercises which are light in character, and that the condition will become worse if the child is subjected to unnecessarily severe muscular exertion. Special braces of all types are inadvisable, because the patient relies on their support and does not make the voluntary effort necessary for correction.

In addition to the infantile type of kyphosis, just described, the deformity occurs at two other widely separated age periods. Thus, the comparatively rapid development of kyphosis in the adolescent has been fully studied by Scheuermann, whose name is usually given to the deformity. The other type of kyphosis, which occurs in old age, is a slowly increasing deformity, to which the description senile kyphosis is usually applied.

ADOLESCENT KYPHOSIS OR SCHEUERMANN'S DISEASE

In this condition the deformity affects chiefly the mid- and lower dorsal regions of the spine, and although affecting either sex it is more commonly seen in boys between the ages of 14 and 17 years, either in those who are employed at heavy manual labour, or as a sequel to some severe illness.

The kyphosis, which is confined to the mid- and lower dorsal regions, usually involves an area extending over 3, 4 or 5 neighbouring vertebræ. The normal antero-posterior curve of the spine in this area is greatly increased, and the abnormal prominence does not disappear entirely, either on recumbency or on suspension (Fig. 83). Some degree of aching is frequently present, but definite pain is uncommon, and if the deformity is left untreated it tends to increase slowly up to the age of 20 or 21 years. As a rule, radiographs taken in the antero-posterior plane show little or no abnormality, but the lateral view shows distinct wedging of the anterior borders of the affected vertebræ with fragmentation of the upper and lower epiphyseal plates (Fig. 84). This is especially seen at their anterior borders, this portion of the plate usually appearing as small isolated fragments of bone, separate and distinct from the bodies of the vertebræ. At first the intervertebral

Fig. 83.—Scheuermann's disease of the dorsal spine.

discs appear mottled and irregular, but later they become more clearly defined. Scheuermann has suggested the analogy of the condition with

FIG. 84.—*Radiograph of early Scheuermann's disease, showing fragmentation of epiphyses and early wedge formation*

Legg-Perthe's disease, and suggests that the fragmentation of the epiphysis is the result of abnormal pressure on the growing epiphyseal plates (Fig. 85).

The work of Schmorl has suggested another possible explanation of the condition. In his opinion, the plate-like epiphyses on the upper and lower surfaces of the body of a vertebra act as buffers against the protrusion and spread of the nucleus pulposus of the intervertebral

Fig. 85.—Old Scheuermann's disease, showing marked wedging of the vertebræ

disc. If this epiphyseal plate is in any way deficient, the nucleus protrudes from its normal site into the substance of the epiphysis, diminishing or destroying the blood supply to the anterior portion of the plate, thus producing a fragmentation and consequent interference with growth.

Treatment

While the condition is acute and the deformity is increasing there is a possibility of at least partial correction of the curve, but as soon as consolidation is complete and the angle of deformity has remained unaltered for some months, then the time for correction has gone. Clinically the period of increasing deformity can be determined by the presence of aching. If the patient states that there is aching in the back on prolonged standing, and that this discomfort is relieved by recumbency, it is probable that the deformity is increasing, but when this period of aching has ceased, consolidation has almost certainly occurred. In the acute stage, while some correction is possible, the patient should be placed on a slightly convex frame, on which gravity tends to correct and not to increase the deformity. This position should be maintained as long as improvement is occurring, after which he should be removed from the frame and placed on a hard mattress on which exercises in the recumbent position should be undertaken for the following 2 months. This period of muscle development is as important as the period of correction, as during this time the muscular control is developed sufficiently to enable him to carry on without support. If, after resuming the upright position, there is any tendency towards the recurrence of deformity, a posterior support should be applied (Fig. 8) as a temporary measure, until the condition is stabilized.

SENILE KYPHOSIS

This is the usual description of a pathological change seen in the spine of elderly patients, the change is characterized by a slowly increasing kyphosis, which is accompanied by diminution, or even obliteration of the normal cervical and lumbar curves. As a rule, the deformity during its development causes aching in the back, but on rare occasions severe pain may be complained of, and some form of support may be required for its alleviation. On account of the increased curve the patient gradually loses height; the shoulders fall forward owing to the loss of muscular tone, and the lateral radiographs show a gradual thinning of the intervertebral discs on their anterior aspects, with usually obvious bony outgrowths from the edges of the neighbouring vertebræ.

Treatment

If the patient complains of severe aching, relief can best be obtained by the application of a suitable support, designed chiefly to prevent the falling forwards of the shoulder girdles. This object is readily attained

by the use of the posterior support which, when padded with a large layer of felt, can be worn by these elderly patients without discomfort, although correction of the deformity is obviously impossible.

TUMOURS OF THE SPINAL COLUMN

Although simple tumours, such as fibromata, chondromata and osteomata, occasionally occur in connection with the vertebræ and their periosteum, tumours of this region are usually malignant in character. These tumours may arise as primary growths of the spinal column, or they may be secondary deposits of malignant growths in some other region. The primary tumours are invariably sarcomata arising usually from the periosteum, while the secondary deposits may be either sarcomata or carcinomata.

CARCINOMA

Carcinoma of the spine occurs as a secondary deposit from a primary growth elsewhere, the spine becoming involved usually by metastatic deposit, although very occasionally it may become involved by local spread. As a rule, the primary growth can be demonstrated in the breast, prostate, thyroid or suprarenal, although in some instances the secondary growth in the spine becomes evident before there are any clinical signs pointing to the primary focus, and in many instances it has been possible to determine the site of the primary tumour only at post-mortem examination.

Clinical Signs

The outstanding feature in almost every case of carcinomatous deposit in the spine is the intense and constant pain which occurs at the site of the tumour, associated usually with girdle pains at the level of the involved spinal segment. Locally, deformity, when present, is slight, or may be absent; occasionally in the advanced stage of the disease the tumour may be palpated through the abdominal wall. The *movements of the spine in the region of the affected vertebra are definitely* restricted, attempts at lateral movement especially causing pain. Progress of the disease is generally comparatively slow, and, as a rule, after discovery of the secondary tumour a fatal result does not occur for 12–36 months.

The radiographic appearance (Fig. 86) is usually quite distinctive, and considerable weight in differential diagnosis may be placed on this feature alone. It indicates that the disease is confined to one vertebral

body, the intervertebral spaces above and below being normal in size. The affected body is compressed in its whole extent from above downwards, as the destruction of the body causes less resistance to the passage of X-rays. Signs of cord involvement may not appear for several months, but when present they are fairly characteristic, in that sensation is involved equally with motor function.

While this type of single secondary malignant deposit can be differentiated comparatively easily, secondary deposits may be widespread in

Fig. 86.—Secondary malignant disease of 1st lumbar vertebra

the spine, especially in the lumbar region In this condition of carcinomatosis the primary growth occurs frequently in the prostate, and the spinal deposits are associated with extensive destruction of the pelvis, giving a radiological appearance whose differentiation from Paget's disease and myelomatosis may cause considerable difficulty.

SARCOMA

This type of tumour is found much less frequently than carcinoma, and may be either a primary or secondary manifestation The signs, symptoms and radiographic appearances are very similar to those of

carcinoma, the chief clinical point of differentiation between the two conditions being the age of the patient, sarcoma usually occurring at a much earlier age than carcinoma.

Treatment

The methods to be adopted in the treatment of carcinoma and sarcoma are identical. As excision of the diseased tissue is obviously impossible the main object of treatment must be the relief of pain, and if possible the retardation of the rate of growth of the tumour. Pain is usually relieved by rest and by immobilization of the spine; thus, the patient can obtain some relief by rest in bed, or by the wearing of a posterior support, which prevents the flexion and rotation strain on the affected area. Deep X-ray therapy is also valuable in relieving pain, while it has a secondary effect of producing fibrosis round the area of disease, thus, to some extent, limiting the spread.

OSTEOMYELITIS OF THE SPINE

This comparatively rare disease occurs most frequently in the dorso-lumbar region of the spine and may be of the acute or sub-acute type (Fig. 87).

The clinical signs are those of a generalized infection with pain, tenderness, rise of temperature, etc. The spine is held rigid in all directions, and over the site of disease there may be found a localized area of œdema and tenderness. Although at first the disease is not accompanied by signs of cord involvement, paraplegia may develop in 3–6 months. The radiographic appearances are typical in the sub-acute stage of the disease and may be distinguished from those of tuberculous arthritis by the involvement of several vertebral bodies, without any great collapse and with a large amount of new bone formation. This new bone is characterized by spike-like projections from the margins of the affected vertebræ, and the presence of these so-called "Parrots Beaks" (Fig. 88) is pathognomonic of the disease.

Treatment

As it is obviously impossible to deal surgically with the area of disease treatment should consist in the administration of penicillin of an amount sufficient to give an adequate blood concentration. The dosage should never be less than 500,000 units per day, continued for at least a month. Under this treatment the spread of the disease ceases, and although it may be impossible to prevent the formation of an abscess, this can be dealt with when its exact location has been determined. At the same time the area of disease must be immobilized on a frame or a plaster bed, and

FIG. 87.—Osteomyelitis of the Lumbar Spine, showing marked new bone formation and density of the affected vertebræ

the fixation maintained until the radiograph indicates the cessation of activity of the infective process.

SYPHILIS OF THE SPINE

Syphilitic affection of the spine may occur, either in inherited syphilis, or in the later tertiary stages of the acquired disease. In either type

FIG. 88.—Osteomyelitis of the Spine, showing "Parrot Beak" formation

it may produce a deformity and give rise to symptoms very similar to those found in Pott's disease.

Diagnosis. Clinically, the disease is in many instances almost identical with Pott's disease, having a sharp antero-posterior deformity with rigidity of the affected portion of the spine. The radiographic changes are also largely destructive in character and may strongly suggest a tuberculous rather than a syphilitic infection, although in the typical case there is more buttressing of the spine by new bone formation (Fig. 89). The diagnosis rests ultimately on the presence of other signs of syphilitic infection, the presence of a positive Wassermann

reaction, either in the blood or cerebrospinal fluid, and the fact that the condition does not tend to improve unless anti-syphilitic treatment is employed.

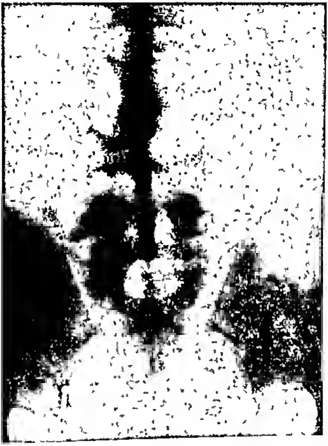


FIG. 89.—Charcot's disease of the Spine.

SPONDYLOLISTHESIS

This deformity of the spine was first recognized by the gynæcologists as a displacement of the body of the 5th lumbar vertebra forward on the upper surface of the sacrum. Although this is the common type of displacement, occasionally the 5th lumbar vertebra remains in its normal position and the 4th lumbar vertebra slides forward on its upper surface. As a rule, in addition to the displacement of the vertebral body, a gap

in its pedicle on each side can be demonstrated by lateral radiographs. The gap usually occurs in the middle of the pedicle between the articular processes, the lower articular process remaining *in situ* with the lamina

FIG. 90.—Spondylolisthesis of 5th lumbar on 1st sacrum.

whilst the superior articulation remains attached to, and slides forward with, the body of the vertebra (Fig. 90).

As has been pointed out by Turner, a division of the pedicles in this region could occur from fracture, but, as many of these patients are young and give no history of an injury likely to cause a fracture of the pedicles, some other explanation of the separation must be sought in

a study of the development of the lower lumbar vertebræ. The ossification of the vertebra starts normally from three centres, one for the body and one on each side for the neural arches. These lateral masses are each originally formed from two granules, an anterior, which forms the pedicle and lateral mass of the body on which the superior articular process develops, and a posterior, which forms the lamina and the posterior articular mass. Failure of the normal fusion of these two primary granules produces a pseudarthrosis; yielding of the fibrous union between these two segments leads to the production of the typical deformity of spondylolisthesis, in which the body of the vertebra first slides forwards and then tilts downwards, so that its superior surface may look almost directly forward. Very occasionally the displacement does not result from a lesion of the arch, but from a complete unlocking of the interarticular processes on one or both sides, so that the neural arch accompanies the vertebral body in its displacement. This severe type of displacement can only result from a severe injury.

Clinical Signs

The displacement appears equally in male and female and is most *frequently recognized in adolescence.* The *trunk appears unduly short,* the umbilicus is lowered towards the pubis, a deep circular groove is seen just above the crest of the ilium, whilst occasionally the body of the displaced vertebra may be palpated through the anterior abdominal wall; posteriorly the upper angle of the sacrum forms a distinct prominence in the middle line of the back.

The patient usually complains of aching round the loin and occasionally of weakness, and in severe cases of almost complete paralysis of the legs. Radiographs, either in the antero-posterior or lateral views, are typical (Fig. 90), that taken in the lateral plane showing the sliding forward of the vertebral body, while in the antero-posterior picture the body of the displaced vertebra casts a large kidney-shaped shadow over the upper part of the sacrum.

Treatment

If the deformity is discovered at an early stage, rest for at least 2 months, and later the application of a closely fitting abdominal or *spinal support,* are usually sufficient to relieve all symptoms, and seem in some cases to promote an improvement in the position of the displaced vertebra. At a later stage, when the displacement is severe, bony fixation of the spine of the 5th lumbar vertebra to that of the 4th and to the upper border of the sacrum gives great relief and restores strength by preventing the sliding forward of the lamina, which alone can produce nipping and pressure on the cauda equina. The operation should be followed by a period of recumbency for at least 3 months, and the wearing

of an adequate corset support is essential when normal activities are resumed.

It has been suggested by Capener and Mercer that a more effective support could be given to the slipping vertebra by the insertion of bony wedges between the anterior inferior margin of the 5th lumbar vertebra and the upper border of the sacrum. Not only is the operation exceedingly difficult but the transferred bony mass becomes compressed by the weight of the body, and its value is soon lost. Very occasionally, if the displacement has already resulted in a pressure paralysis of the cauda equina, laminectomy may be indicated.

VERTEBRAL OSTEOCHONDRITIS OR CALVÉ'S DISEASE

An affection of the spine which is commonly found between the ages of 4 and 10 years as a localized kyphos of the dorso-lumbar region, accompanied by pain over the site of the kyphos radiating round the abdomen, and clinically resembling very closely tuberculous disease of the spine.

The differential diagnosis is made almost entirely by a study of the lateral radiographic view of the spine, which shows that only one vertebral body is affected. This appears flattened, somewhat wedged and casts a very dense shadow, the intervertebral discs above and below being unaffected. The course of the disease is usually short, and after a time some reconstruction of the vertebral body can be demonstrated.

Treatment

Rest in the recumbent position for a period of 3–6 months, or the wearing of a posterior spinal support is usually sufficient to relieve the symptoms and prevent further compression of the affected vertebræ.

KÜMMELL'S DISEASE

A condition of osteitis of one vertebral body, usually occurring in adult life, in which the body of the affected vertebra becomes gradually compressed and assumes a definite wedge deformity.

Etiology

The etiology of the condition is obscure, but it is now generally agreed that the process is not the result of inflammation or infection, as was originally thought, but is probably due to the occurrence in the body of the vertebra of a crack fracture, which was undiscovered and untreated.

Following some comparatively slight injury the patient apparently recovered completely. After a varying interval of comfort there is usually a complaint of pain and aching which, in the absence of treatment, may increase and may be accompanied by weakness or even by definite paralysis of the legs.

Differential Diagnosis

From Pott's Disease. The two conditions may be distinguished by the wedging of a single vertebra, as shown in the lateral radiograph, by the absence of involvement of the neighbouring intervertebral discs, and by the absence of any shadow indicative of abscess formation.

From Malignant Disease. By the wedging of the affected vertebra in contrast with the compression which occurs in malignant disease, and by the further resistance of the compressed vertebra to the passage of X-rays.

From Congenital Wedging With this deformity of one or more vertebræ there is, as a rule, no complaint of pain or aching, while the vertebral wedging appears in the antero-posterior radiograph and not in the lateral view

Treatment

If the aching is severe, relief can be obtained by recumbency for a period of 3 months, followed by the wearing of a posterior support for the following 6 months. Very occasionally, if, in spite of wearing a suitable support, aching and pain persist, a spinal fusion may be necessary.

ARTHRITIS DEFORMANS OF THE SPINE

This extremely disabling disease occurs almost invariably in adult life, although a condition which is very closely allied to it is found occasionally in children suffering from generalized rheumatoid arthritis.

The first changes appear in young adult life in the sacro-iliac joints, which show extensive destruction proceeding steadily to ankylosis (Fig. 91). Later, calcification and ossification occur in the ligaments and periosteum of the affected areas of the spine The process of alteration of the ligaments into bony masses appears first along the anterior or lateral ligaments of the spine, and is accompanied by atrophy of the intervertebral discs, which occasionally also show definite calcification, leading to a still greater rigidity.

Under the general title of arthritis deformans are included types which, though differing from each other in some respects, show little distinction in their etiology or in their pathological basis. Thus, the condition may be classified under four headings:—

1. In the first group are included those patients in whom the calcification is simply a manifestation of a generalized infective

Fig. 91.—Spondylitis of Lumbar Spine, showing ankylosis of both sacro-iliac joints.

polyarthritis, in which the spine has been involved together with most of the other joints in the body.

2. Where the spinal rigidity is associated with involvement of a few other large joints, such as the hips and shoulders, the type characteristic of the so-called *Spondylitis Rhizômélique* of Marie.

3. Where the disease may be limited to the spine, a condition

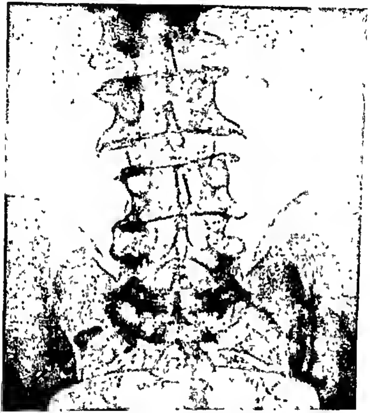


FIG 92.—Chronic Osteoarthritis of Lumbar Spine

which is most frequently found in male patients between 20 and 40 years of age.

4. This fourth group shows characteristics which differ considerably from the other types, as the osteoarthritis (Fig. 92) is found commonly in the lumbar spine of labourers engaged in heavy work. This condition is probably traumatic in origin and is not usually accompanied by ligamentous ossification

Signs

As a rule, the first signs are those of so-called "Muscular Rheumatism" or "Lumbago." The patient feels the back stiff and complains of aching, especially if he has remained at rest in one position for any length of time. These attacks return with rapidly diminishing intervals until the spine appears to be completely locked through almost its whole extent. Finally, practically the whole spine becomes rigid, and the normal curves are obliterated, although movement may be retained in the cervical region long after the other spinal movements have disappeared. With the loss of the normal lordosis the patient cannot stand up straight, but walks with the spine curved forward in one single arc from the sacrum to the occiput.

Etiology

It was formerly believed that this disease was predisposed to by a previous gonorrhœal infection, but investigation of large numbers of soldier patients proves that this type of infection has no influence on the occurrence of the disease. Excessive strain and unaccustomed concentrated physical and nervous fatigue would appear to be so constant in the previous histories of these patients, that they must be given weight as predisposing factors.

Trauma may also be a factor in any of the four types, but seems to be the main predisposing cause in the so-called fourth type, where the bony outgrowths constitute the reaction of the tissues to the constantly repeated slight injuries sustained at heavy work, and in which infection plays only a minor part.

Treatment

If the source of the primary infection can be established it must be dealt with efficiently. Chronic infection of any type should be treated with vaccines, ionization, or by wide opening up of the infected area. Unfortunately no decided improvement has followed treatment by vaccines, but a course of gold injections has, in some instances, led to a diminution of pain and an apparent cessation of the progress of the disease.

Relief of pain is almost certain after the administration of a course of wide field X-ray therapy over the affected area of the spine. Cures of the disease have been claimed as the result of this type of treatment, but unfortunately relief of symptoms and a temporary arrest of the activity of the disease seem to be the most to be expected.

Clinically it is obvious that the spine must be retained in the straight position in order that function of the thoracic and abdominal organs

may be interfered with as little as possible, especially when the ligamentous consolidation is complete.

Usually the patient comes for treatment when the spine is already in a position of flexion. If the ligamentous calcification is already complete and solid the patient does not complain of any aching or pain in the back, although there may be discomfort in the thighs and feet, but if after working the patient complains of an increase in the aching and pain in the back, it is obvious that the deformity will increase unless the spine is supported and this yielding prevented. This clinical observation may be taken as an indication of the possibilities of correction of any deformity already present. The occurrence of aching as a result of prolonged exercises proves the probability of increase in the deformity, and indicates equally the possibility of correction following recumbent treatment. In the absence of such aching, correction of any deformity already present is impossible by conservative means, but a correction of the extreme kyphos can be secured by the operation suggested by Smith-Petersen, in which, after excision of the articular facets of two neighbouring vertebræ at the apex of the curve, the spine is straightened by osteotomy of one of the vertebral bodies. The operation is dangerous, after correction of the deformity paralysis of the lower limbs has been produced in some instances, but the operation can be considered in an extreme deformity.

The method of slow, gradual straightening, applicable to those patients in whom aching in the back is present, is extremely simple; the patient should be placed recumbent on a straight frame on which the action of gravity alone produces a slow and gradual straightening. This correction is continued until the spine is almost straight, when the patient is allowed to walk with the help of a suitable posterior spinal support. Where the cervical spine has also become involved in the calcification the addition of a collar support is also necessary. When correcting the deformity the surgeon must remember that an over-extended and rigid spine gives an even greater amount of discomfort and disability than one in which there is still a slight amount of flexion deformity. For this reason correction should cease before the spine has become fully straightened, the ideal position being that in which the patient, when standing upright, can look straight in front. Subsequent to its correction, radiant heat and massage of the spine lead to an improvement in the circulation and a diminution in the discomfort.

The posterior support should be worn for at least 6 months and may be discarded gradually, being removed first at night and later for a portion of the day. If no increase of the deformity follows this period of freedom the intervals may be lengthened until complete freedom is allowed.

AFFECTIONS OF THE LUMBO-SACRAL REGION AND SCIATICA

Persistent backache, with or without pain referred down the sciatic nerve, is an extremely common complaint, especially in women, and may be due to such a widespread variety of causes that the true diagnosis is always a matter of considerable difficulty. This series of symptoms may arise from bony abnormalities of the lumbo-sacral or sacro-iliac regions, but an almost identical clinical picture may be caused by gynæcological conditions, chronic constipation, growths and abnormalities of the lower bowel, or disease of the urinary tract. Associated with the chronic backache there may be an intermittent or persistent sciatica, which may have preceded or followed the onset of the backache, and which may or may not be due to the same abnormal conditions which caused the backache. Thus, whilst the patient may have a definite bony deformity of the lumbo-sacral or sacro-iliac region, there may at the same time be some other condition, such as chronic constipation or an abnormal pelvic condition, which may cause or aggravate the symptoms complained of. When the various abnormal conditions present have been demonstrated and considered, and it is evident that the aching and pain are not due entirely or chiefly to any intra-abdominal or intra-pelvic condition, the pelvis and lumbar spine should be considered as possible causes of the disability.

Lumbo-sacral and Sacro-Iliac Strain

The possibility of strain of the lumbo-sacral joint depends largely on the relation of the sacrum to the lumbar spine. In the erect position of the body with the sacrum in the average position, in which its lower extremity is tilted backwards about 15–20 degrees in relation to its upper border, strain of the joint follows only on very severe trauma. When this angle between the sacrum and the lumbar spine is greatly increased, as it is in most women, abnormal stress constantly applied to the ligaments of this area renders the patient liable to chronic stretching of the ligaments and persistent aching pain.

Strain of the sacro-iliac joints, which is also predominantly a female complaint, is most probably caused by the comparative laxity of the female sacro-iliac joint in comparison with the male. This provision of nature, which allows of extra movements at childbirth, renders the joints more vulnerable, especially in the periods of generalized pelvic congestion, when the sacro-iliac ligaments also become less rigid.

Symptoms and Signs

These two conditions of lumbo-sacral and sacro-iliac strain are frequently very difficult to distinguish by a study of the signs and symptoms

present. Thus, in each case, aching is present over the region of the sacrum, with pains shooting down the thighs; again, rest in bed in a comfortable position usually gives complete relief, but in the acute stage, turning over in bed may cause so much pain that the movement is not repeated.

There are, however, certain differentiating points between the two lesions:

1. Pain from sacro-iliac strain is usually complained of down the back of the hip and thighs, whilst that caused by lumbo-sacral strain passes down the front and outer side of the thigh and leg.

2. Tenderness on pressure is present in the lumbo-sacral strain over the tip of the 4th and 5th lumbar *vertebræ, whilst that in* sacro-iliac strain is most definitely along the posterior border of the ilium over the sacro-iliac joint.

3. Rigidity of the lumbar spine is, as a rule, more marked in lumbo-sacral strain than in sacro-iliac strain.

Etiology

The condition of strain of either of these joints may arise with or without any definite trauma. Probably the commonest history in a woman is that, since childbirth, the pain has persisted and has diminished only to a slight degree. On many occasions the cause of the strain would appear to be long-continued standing at work, especially where *no interval of rest is provided. Very occasionally some definite injury,* such as jumping from a height, or being involved in a motor-car accident, was the exciting cause.

Differential Diagnosis

As already stated, the differential diagnosis is often extremely difficult, as many pathological conditions of the abdominal and pelvic contents can cause a similar train of symptoms. Arthritis of the sacro-iliac joints, whether infective or tuberculous in origin, can usually be distinguished by the localized signs, and by the radiographic appearances, while such disabilities as chronic lumbago give a less severe and more widespread tenderness and partial rigidity of the whole of the lumbar region.

Treatment

With severe pain, rest is essential; the duration of recumbency naturally varies with the acuteness of the disability, but, as a rule, rest should be continued for at least 2 weeks. When activity is again permitted, errors of posture must be corrected by suitable shoe alterations and by muscle training, which help the patient to control the spine and to maintain the correct position. Massage of the spinal muscles is of

considerable help in improving muscle tone and diminishing spasm, while direct support to the strained joints can be provided by the application of a suitable strong belt (Fig. 93). The belt, which is designed to hold the joints together, should, if giving relief, be worn continuously until the tenderness and pain have disappeared, when it may gradually be discarded.

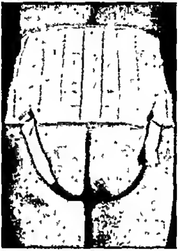


Fig. 93.—Sacro-iliac Belt.

Manipulation. As in every case of ligamentous strain, prolonged disability is usually the result of the formation of adhesions round the site of strain, which invariably occurs at the insertion of the ligament into bone. The presence of such adhesions is suggested by the absence of any bony abnormality, as shown in the radiograph, by the persistence of pain on exercise, and limitation of movements of the lumbar spine, especially in one or two directions. When such a clinical picture is present, manipulation of the affected area will often produce very considerable improvement, both as regards the range of movements and the relief of symptoms.

The manipulation is carried out under full anæsthesia. The spine is first flexed to, but not beyond the full normal range, the feet being placed in line with the top of the head; the full range of extension of the spine is then produced by lifting the patient's pelvis from the table, allowing the head and feet to fall back passively, no extra force being used to produce hyperextension. Rotary movements of the affected area are performed by rotating the pelvis through the medium of the adducted thighs. After manipulation, treatment is carried on as before by the application of a belt, and by exercises and massage during the temporary period of increased tenderness which follows the manipulation. As a rule, in strains of the lumbo-sacral joint considerable relief follows the manipulation and the subsequent wearing of a suitable belt, and no more radical type of treatment is usually required.

Operation for persistent Sacro-iliac Strain. If, in spite of manipulation, followed by the wearing of a suitable belt, pain still persists in the sacro-iliac joint, the operation of stabilization of the loose joint, either by the method of extra-articular fusion, as described in Chapter IX, or by the less severe and more reliable procedure of intra-articular fixation by bone-pegging, as described by Smith-Petersen, may be advisable.

Smith-Petersen's Bone-pegging Operation. Here an attempt is made to prevent all movement at the joint by means of a wide bone peg, which is inserted through the substance of the ilium into the sacrum (Fig. 94). The technique is as follows: the outer aspect of the ilium posteriorly is approached through a 9-inch incision along the outer posterior border of the crest of the ilium. The muscles attached to the outer margin of the crest are cleared by cutting through their tendinous origin close to the crest, and the muscle mass is then removed from the outer aspect of the bone by blunt dissection down the upper border of the sacro-sciatic notch. The centre of the sacro-iliac joint is marked as a point on the outer plate of the ilium by measuring $1\frac{1}{2}$ inches in front of the posterior margin of the crest and $1\frac{1}{2}$ inches below the crest

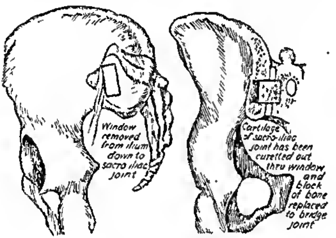


FIG. 94.—Diagram of Smith-Petersen's bone pegging operation for stabilization of the Sacro iliac Joint.

at this level. At this point a quadrilateral section of the ilium, about $1\frac{1}{2}$ inches by 1 inch, is removed. This part of the operation requires patience, but, *with care and by using special chisels* slightly curved on the flat, it is possible to remove the whole wedge of the ilium with the subjacent portion of the sacro-iliac joint, and a small part of the lateral mass of the sacrum. The portion of the joint in the bony section is now removed, and the iliac wedge is countersunk through the cavity into the substance of the sacrum.

Three to four months' fixation in recumbency is necessary after the operation, before weight-bearing can be safely resumed, support of the joint being continued by the wearing of a firm, closely fitting belt.

SCIATICA DUE TO LESION OF INTERVERTEBRAL DISCS

The intervertebral discs are composed of two distinct elements, a peripheral rim or annulus fibrosis, in which the fibres run obliquely and are joined to the margins of the vertebræ above and below. Enclosed in the centre of this strong circular mass is a soft pulpy core, the nucleus pulposus, which by its elasticity maintains the normal configuration of the disc. If the annulus is injured at any point the central core, or nucleus, may protrude; thus, the nucleus may be displaced laterally, forward, backward, or into the substance of one of the neighbouring vertebræ.

Mixter and Barr (1934) demonstrated that with a posterior displacement of the nucleus into the spinal canal, pressure could be exerted on the neighbouring nerve roots, causing a persistent pain which, in some instances, could not be relieved by physiotherapeutic measures. Lesions of the intervertebral discs of this type may occur at any level in the spine but, because of the great pressure normally thrown on the lower lumbar region, this injury is most commonly seen in the space between the 4th and 5th lumbar vertebræ, or in that between the 5th lumbar and 1st sacral segment. In this region, pressure on the emerging nerves can cause pain referred to the sciatic distribution, and it is now recognized that this nuclear displacement is often the cause of an intractable sciatica.

The signs and symptoms which are produced by the displacement are persistent pain, usually not relieved by rest, changes of sensation, and tingling on the outer side of the calf or foot, and occasionally accompanied by a loss of ankle-jerk. There may in addition be some paralysis or weakness in one of the muscle groups supplied by the sciatic nerve; most commonly this loss of power is seen in the peroneal group.

Many tests have been used in an effort to diagnose the condition; thus, radiographically opaque material has been injected into the dural cavity in an effort to define and localize the site of the protrusion. This test has been discarded as unreliable, and the examination of the cerebro-spinal fluid has not added anything in the differentiation of the lesion.

Differential Diagnosis

The clinical picture is so closely patterned on that caused by a sciatic neuritis, that the differentiation is always extremely difficult. The greatest reliance must be placed on the response of the patient to treatment; if after complete recumbency of two months, in a patient in whom no other cause for sciatica can be found, there is no improvement, the presence of a retropulsed disc may be assumed.

Treatment

Operative treatment alone holds out hope of cure or improvement. The *technique* employed varies from removal of the disc after laminectomy and inspection of the area, to the removal of the protrusion through an interlaminar approach without removing bone. When the protrusion has been identified it is cleared out with a sharp spoon, and the operation completed by scraping out as much as possible of the remaining portion of the affected disc. Bony fusion of the spinous process and lamina of the vertebræ above and below the protrusion, either at the time of operation or at a later date, is often employed in order to prevent the pain which may follow the alteration in the normal spinal alignment, and the change in relationship of the articular facets.

CONGENITAL DEFORMITIES

Spina Bifida

Failure of the normal process of fusion of a neural arch may be present in any region of the spine, although occurring most commonly in connection with the lower lumbar and upper sacral vertebral segments. Owing to this failure there is left in the posterior bony wall of the vertebral canal an opening, which may be a simple slit between two closely approximated lateral segments, or a wide gap in which the laminæ are represented by two minute bony projections extending backwards from the lateral aspects of the affected vertebral bodies. With the simple slit in the bony wall, protrusion of the contents of the canal does not occur, but accompanying the wide opening there is, as a rule, a large protrusion which may, or may not, contain neural elements.

As a result of this failure in the wall of the canal, there may be weakness of the legs, or even paraplegia when the opening is wide and the protrusion is extensive, while the simple failure of fusion of two almost complete laminæ may cause no symptoms in the child, and may be indicated simply by a growth of hair on the skin over the lumbar spine.

Surgical closure of an extensive spina bifida is usually desirable and should be carried out at an early age, but no attempt should be made to produce bony fusion in the simple central cleft, even when recognized in the child.

Although this apparently slight abnormality causes no disability in the early years of life, aching and pain may be complained of in middle life, when relief can be obtained either by bony fusion of the affected area, or by the use of an efficient surgical corset. As a rule the support of the corset is sufficient to give complete relief, but when pain persists after its application, bony fusion of the affected laminæ to the healthy spinous processes above and below is usually adequate.

Sacralization of the 5th Lumbar Vertebra

When the transverse process of the 5th lumbar vertebra is so greatly enlarged as to appear almost as part of the lateral wall of the sacrum, the description of sacralization is given to the abnormality (Fig. 95). It may be present as a unilateral or bilateral deformity and, as a rule, causes no discomfort or disability to the patient. The abnormality is

FIG. 95.—Sacralization of the transverse process of the 5th Lumbar Vertebra on left side.

usually recognized only in the course of routine radiographic examination, and should be considered as of little significance.

Extra Lumbar Vertebra

Occasionally persistent aching in the spine can be attributed to the presence of 6 vertebræ of the lumbar type. The complaints of aching and tiredness, as a rule, are only present during adolescence and young adult life, disappearing when the muscular control is fully developed. The wearing of a suitable corset, combined with exercises, leads to a rapid improvement in the patient's stance, and to cessation of the complaints.

CHAPTER XIV

LATERAL CURVATURE OF THE SPINE

Lateral curvature, or scoliosis, consists essentially of a persistent deviation of some or all of the vertebræ from the middle line of the body. This simple lateral displacement of the column forms one part of the deformity, the other consisting of a rotation of each of the displaced vertebræ to a varying degree. The rotation occurs round an axis passing down the centre of the spinal canal, the vertebral bodies rotating through a larger arc than their spinous processes, which remain nearer the middle line of the body.

Sex and Age. In young children the deformity is found in practically the same proportions among male and female, but later, when adolescence is reached, there is a persistent increase in the percentage of females affected as compared with males, to such an extent that in children requiring treatment the proportions are 5 females to 1 male. It is difficult to explain the reason for this disparity between the sexes, but a possible explanation can be found in the fact that the general body changes occurring at puberty cast a much greater strain on the less robust female frame. It is possible also that a slight spinal deformity, which would be masked by the better muscle development in the male, is more easily recognized in the less sturdy female

An exact estimate of the time of onset of the deformity is difficult or impossible. In most instances when the child is brought to the surgeon the deformity has already existed for some considerable time, and its recognition is often due to the attentions of the tailor or dressmaker who has discovered that one hip is more prominent than the other, or that one shoulder is persistently higher, and that special alterations to the clothes are necessary. The only criterion we have as to the common age of onset of the deformity is the age at which the child is brought to the surgeon or gymnast for treatment. Seventy per cent of these children are between the ages of 10 and 16 years—the period when growth is most active and when abnormal strains on the tissues are most likely to result in permanent deformities.

SYMPTOMS

As a rule, except in the most extreme instances, the deformity is not accompanied by any symptoms. There are, however, two classes of patients in whom even a slight deviation may produce symptoms of aching and tiredness in the back, especially after moderate exercise or games. These are the highly strung, neurotic patients, or the very tall

overgrown girls who may complain of tiredness and aching in the spine even after a comparatively short walk. These two exceptions to the general rule serve only to emphasize the truth of the statement that the condition is symptomless until the deformity has reached an extreme stage, and that, in the presence of a mild scoliotic deformity, the cause of any severe and persistent pain must be sought elsewhere. When the deformity has become so advanced that the ribs on the concave side have approached, or are touching, the brim of the pelvis, intermittent shooting pain may occur as the result of pressure between these bony structures. In the elderly patient, where the deformity is severe and of long duration, bony changes take place at the sides of the bodies of the vertebræ, leading to narrowing of the intervertebral spaces with osteophytic outgrowths, and in some cases such changes produce severe girdle or root pains by pressure on the emerging nerves. General symptoms of breathlessness and fainting may also occur with severe deformity of the thoracic cavity, owing to displacement and pressure on the heart and lungs, while disorders of digestion are comparatively common sequelæ of the increased intra-abdominal pressure and displacement of organs which result from the fall of the thorax and diaphragm.

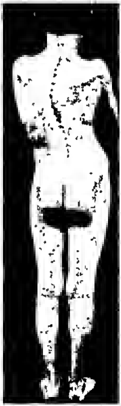


FIG. 96.—Left dorsal postural Scoliosis.

Description. Scoliosis is defined as a deviation of the spine to one or other side of the middle line, and, in describing a particular deformity, use is made of this to indicate the direction and locality of the curve. Thus, a convexity of the spine to the right of the middle line is described as a right-sided scoliosis, and vice versa (Fig. 96). Similarly, if the convexity is in the thoracic region to the right of the middle line, the description given is a right dorsal scoliosis. The curvature is seldom a single one, and if a curve is present in the right thoracic region there is usually a second or compensatory curve to the other side in the lumbar, and frequently also in the cervical regions. There may be considerable difficulty in deciding which of the three curves is the primary one, but it is usually possible to determine which is the important one from the point of view of treatment. When this primary or predominating curve has been successfully treated the secondary curves do not, as a rule, give rise to any trouble, as their deformity is usually mobile, or at least not so fixed as that of the original curve, which has been of longer duration.

Examination. Examination of a suspected case of scoliosis is carried out with the back, chest and pelvis completely exposed, so that all deviations from the normal line can be appreciated. Deviations of the spine from the middle line, which persist in spite of voluntary efforts to straighten the back, are an indication of the presence of lateral curvature.

Prominence of the lumbar spine on one side with apparent raising of the other hip and increase of the loin angle indicate the presence of a lumbar scoliosis. Projection of the chest backward on one side, with a raising of the scapula on the same side, and a flattening of the other side of the chest, are seen in thoracic scoliosis. On inspection from the front in a case of thoracic deformity, the chest is prominent anteriorly on the side of the posterior concavity, and depressed in front on the side which is prominent posteriorly. Although the posterior projection of the chest-wall can be seen while the patient is standing upright, its extent can be appreciated more easily when an attempt is made to touch the toes *with the knees straight.* In this position, the rotation of the vertebræ, which produces the prominence of the ribs or of the lumbar transverse processes, is seen to its full extent, and can be measured. In structural scoliosis the prominence of the ribs posteriorly on flexion of the spine is always seen on the side of the convexity, but in the case of a long single or postural curve there is usually no backward projection of the ribs on flexion.

Movements. All movements of the spine must be carefully measured. This examination is carried out first while the patient is standing, later while in the recumbent position. It will be seen that, with absence of extreme secondary bone changes, movements are free in all directions, except for a slight limitation in the area of deformity when the attempted movement is lateral and towards the side of the deformity.

Radiographic Examination. This will demonstrate the deviation of the bodies of the vertebræ from the middle line to be greater than is expected from the clinical findings. It will show also the presence of wedging of the bodies of the vertebræ which occurs on the side of the concavity sooner or later in every case of fixed structural scoliosis. It will also indicate the presence or absence of congenital deformities, either of the vertebræ or of the ribs, and if any of these structural alterations of the bony framework are present, the impossibility of a complete anatomical correction of the deformity can be appreciated.

Types of Scoliosis

There are two distinct clinical types of scoliosis which vary from each other both in regard to structural alterations and the treatment which must be adopted for their relief:

(*a*) Postural or Mobile. (*b*) Structural or Fixed.

(a) Postural or Mobile Scoliosis. This group has also been given the name of total scoliosis owing to the fact that the curve is usually single, extending from the cervico-dorsal region to the lumbo-sacral angle. No secondary or compensatory curves are present above or below the primary one, and deviation of the spinous processes at the maximum point is not more than $1\frac{1}{2}$–2 inches from the middle line.

On examination of the spine in the erect position there is a long gentle curve with the spinous processes deviated to one or other side, usually the left, with slight posterior bulging of the ribs on the side of the convexity. When the spine is examined in the flexed position this bulging disappears and no deformity is present, although occasionally slight posterior bulging may be seen on the opposite side. Complete disappearance of the deformity also follows suspension of the patient by the hands or on the assumption of the position of recumbency. Normal mobility is present in every direction all over the spine, and the radiograph, beyond showing slight deviation from the middle line of the body, reveals no bony abnormality; in fact, this deviation can only be shown when the photograph has been taken with the patient in the upright position.

As a rule, postural or mobile scoliosis is only a temporary deformity and disappears in the course of a few years, either with or without treatment. On rare occasions, if the condition has been left untreated for several years, definite structural alterations may occur in the bones, ligaments and muscles, and the deformity is then changed from a mobile to a rigid structural scoliosis, but this alteration from a postural to a structural scoliosis is the exception and not the rule.

(b) Structural or Fixed Scoliosis. In this group the deviation and rotation of the spine, which are evident when the patient is in the erect position, do not disappear on flexion, suspension or in recumbency. In the early stages there may be only a single primary deformity, but when this has become more advanced secondary or compensatory curves appear above or below the primary curve. The essential feature in this group is that, in every instance, bony deformity of the vertebræ is present, either as a result of yielding of the growing bony tissues to abnormal strain, or because of the presence of a true congenital bone deformity.

Alterations develop in the other thoracic structures secondary to this bony change in the vertebral bodies; thus, the ligaments on the concave side of the deformity become contracted and thickened, while those on the convexity become elongated and thinned. A similar alteration takes place in the muscles governing the spine, and later changes occur in the shape of the ribs themselves. These bony alterations in the thoracic wall can be appreciated clinically and radiographically. In a severe deformity the ribs on the convex side project backwards behind the spinous processes of the vertebræ, while on the concave side they lie

well in front of this line. The angles of the ribs can be felt to be considerably altered over this posterior prominence, being sharper than normal, in some cases the angle of the ribs being so acute as to form a sharp bony line under the skin, giving rise to the description of "Razor

Fig. 97.—Radiograph of right dorsal Scoliosis, showing deformity of ribs with early wedging of vertebræ.

Back." On the concave side of the spine the ribs are flattened so that the site of the angle cannot be appreciated, and the rib appears as a flat plate of bone. The deformities of the vertebræ can best be appreciated by examination of the antero-posterior radiographs, which usually show a definite lateral wedging of one or more vertebræ, the site of the greatest wedging being usually at the apex of the curve (Fig. 97). This distortion of the vertebral body may either be acquired as a result of long-continued pressure on one aspect of the growing bone, or may be a true congenital deformity, the differentiation between these two types of wedging being often extremely difficult.

If the wedging is confined to one vertebra, then the probability is that the deformity is congenital in origin, but if there is a definite wedging of several neighbouring vertebræ, with no other congenital bone abnormality, then it is probable that it has been caused by abnormal pressure. The intervertebral discs also show changes at a very early stage; in fact, these changes are usually present before any definite alteration occurs in the bony structure. On the concave side of the deformity the discs are squeezed out and project beyond the margins of the neighbouring vertebræ. On the convex side, however, they are definitely thicker than normal and do not extend beyond the lateral border of the vertebral bodies.

Causes of Scoliosis

The causes of scoliosis may be

1. Congenital.
2. Acquired.

Congenital

(a) Definite bony abnormality of the vertebræ.

(b) Prolonged intra-uterine fixation in the scoliotic position without definite bone changes.

Acquired.

(a) Positional, due to improper muscle balance.

(b) Alterations in line of the pelvis—short leg.

(c) Alterations in muscle balance due to infantile paralysis.

(d) Alterations in balance on the two sides of the chest—empyema and phthisis.

(e) Softening of bones—rachitis, osteomalacia, etc.

(f) Secondary to other deformities, torticollis, Sprengel's, etc.

Prognosis

In the postural type, with suitable treatment the prognosis is good and a cure of the condition is to be expected.

In the structural type, where definite bony deformity is present, cure is impossible, but some improvement in the alignment of the back

can usually be obtained. The older the patient when coming under treatment for the first time the worse the prognosis on account of the greater fixity of the soft tissues, and the greater resistance of the deformed bone to any corrective force.

Treatment

Postural Scoliosis

Treatment for this deformity consists largely in building up the child's muscular control, thereby *correcting the tendency to deformity*, and at the same time dealing with any cause of deformity, such as the habit of continually standing on one leg, sitting on one buttock, or always carrying a bag on one shoulder. In many instances the child is tall and overgrown, and probably is already doing vigorous gymnastic exercises, which tend only to tire the muscles and increase rather than diminish the displacement. When exercises are used in treatment they should be so arranged that the child's musculature is not overtired. Intervals of rest in a recumbent position for at least one hour a day should be insisted upon, and simple bending and straightening exercises and swimming should be included in the course, as in this way an improvement is obtained in the muscle tone without the strain of gravity No form of support or shoulder-strap is usually necessary or advisable, and the child must be constantly reminded to hold the erect position. If the exercises are carried out conscientiously the result is generally excellent.

Structural Scoliosis

The problem here is entirely different; already a definite alteration has occurred from the normal, both in the soft and bony tissues of the spine, and any alterations or improvement of the deformity require prolonged and persistent treatment In dealing with a patient suffering from structural scoliosis it is necessary first to decide whether any correction can possibly be obtained or whether our efforts should be devoted *to the prevention of increase in the deformity already present*. This question in regard to the possibility of improvement can readily be determined by the effect on the deformity of suspension of the patient by the hands, the feet being clear of the floor. If no alteration follows the suspension, then correction is impossible, but if there is a definite improvement in the alignment of the spine and a diminution in the curvature as a result of the suspension, then correction, at least to that improved position, is to be expected with suitable treatment.

In the presence of *structural alteration in the spine*, *if suspension* from the hands causes no alteration in the curve, then treatment by supporting casts or jackets is only necessary when there has been an increase in the deformity during the previous 2 or 3 years, or when pain is present in the back. If we can be sure that there has been no increase

of the curve, and that the deformity is not causing pain, then the object of treatment must simply be the improvement of the muscle tone, alteration of the stance of the body by suitable gymnastic exercises, and, when advisable, change in the alignment of the pelvis by raising the heel of the shoe on one or other side, or the correction of any other deformity in other areas, such as the neck, which may tend to increase the curvature. If, however, deformity has increased, or if pain is present in the spine, then a fixed supporting cast must be applied until the spine again becomes stable and painless.

Attempts at corrective treatment of structural scoliosis should be confined to that group where a definite improvement in the line of the deformity is produced by suspension. In this group improvement follows treatment, either by a partial correction of the fixed curve, or, more frequently, by increasing the secondary curves above and below the primary deformity. Some improvement in the fixed deformity follows on prolonged fixation of the spine in the optimum position obtained by suspension. In this position the excessive pressure, which has previously been borne on the concave aspect of the spine, is reduced, the weight being borne more evenly over the whole surface of the vertebral bodies, the ligaments on the side of the convexity being thereby relieved from constant overstretching. The steadily increasing wedging of the bodies of the vertebræ is prevented and the ligaments and muscles on the convexity of the spine become shorter and act at a better mechanical advantage.

The active treatment of structural scoliosis may be divided into three groups:

(a) **Gymnastic Exercises**, which by themselves are only suitable for those patients in whom the structural deformity is slight and the general physical condition is such that strenuous muscular exertion can be undertaken without detriment to health.

The exercises are of two types:

Group I. Simple general muscular exercises of the muscles of the spinal group. These lead to improvement in the tone of all the muscles acting on the spine, although they cannot in any way alter the disproportion already existing between the two opposing groups.

Group II. Specialized exercises designed to stretch the muscles on the concave side of the spinal deformity, so that their opponents may be able more effectively to control the alignment of the spine.

There are certain other practical points which must be followed in the treatment of this type of patient.

(1) The pelvis must be kept level; if one limb is shorter than the other, the pelvis level must be corrected by raising the shoe on the depressed side until equality is obtained.

(2) In the presence of flat-foot deformity—a condition frequently found in these scoliotic subjects—instructions must be given as to alterations to shoes and exercises for the correction of this disability.

(3) The exercises must never tire the patient, care being taken that breathing exercises are always arranged between those of a more strenuous nature.

While this form of treatment by corrective muscular exercises is of value in those early cases where the deformity is not severe, it must not be persisted in in the face of an increasing deformity, and where this is obvious some more effective method must be adopted.

(b) Corrective Moulding. Where bony changes are already present in the spine, complete correction of the deformity can never be obtained by any form of treatment. Considerable improvement in the appearance of the deformity usually follows on prolonged moulding of the spine in a corrective plaster jacket. These casts may be applied, either with the spine fully extended or while it is in a position of flexion, the former method being the one usually employed in the correction

In applying the corrective plaster the patient is suspended by the head and arms, so that the heels are off the ground and only the toes touch the floor. The plaster case is then applied closely to the body over a layer of stockinet and wool, from just above the great trochanter to at least the level of the middle of the scapulæ. While damp, the plaster is very carefully and firmly moulded over the posterior convexity of the chest, especially over its lower border and over the crests of the ilia, thus stabilizing the pelvis and the convexity of the chest in the optimum position obtainable by suspension The plaster, which is allowed to set firmly before the suspension is removed, is subsequently cut out on the concave side so that expansion of the chest can occur towards this aspect. The lower border of the case is cut on the front of the thighs, enabling the patient to sit without pressure on the groins, while the edges of the cast are smoothed off to prevent injury to the skin.

The first corrective case is retained only for a short period, as it soon becomes apparent that its corrective action has been lost. A series of casts are employed during the next 6 months, on each occasion the alteration being necessary because of slackness which has developed between the cast and the chest-wall This reapplication is continued so long as any further improvement in the deformity can be obtained by suspension. When the point of optimum correction has been reached the cast should be removed and a decision arrived at as to the best method of retaining the correction.

Where the correction has been almost complete, recurrence of the deformity may be prevented by improving the muscular control of the spine through a course of exercises, which are at first carried out with the patient in the recumbent position. As a rule, however, some addi-

tional support, either external or internal, is necessary as a protection against the reappearance of the deformity. The simplest and probably the most efficient external support is a removable celluloid cast which maintains the correction obtained by the plaster casts. The cast should be removed two or three times daily for short intervals of massage and exercises, and this routine should be continued until the muscular control of the spine is sufficient to retain the correction. The exercises should always be supervised by a skilled masseuse, who can regulate their severity and can prevent the tendency towards slackness which is shown by every patient when the same routine has to be practised over a long period.

(*c*) **Bony Fixation of the Spine.** When it is decided that, in spite of any form of external fixation, increase of the deformity is likely to occur, then fixation of the spine by the method of Albee or Hibbs is a justifiable procedure. Before such an operation is carried out all possible correction of the deformity must be obtained by means of exercises, corrective plasters, or recumbency. A definite decision as to the advisability of the operation should, if possible, be postponed until the patient is 15 years of age, when true bony fusion is more likely to follow and when there is comparatively little tendency to recurrence of the deformity.

The operative procedure has been described in Chapter IX. As it is impossible and inadvisable to fuse the whole of the primary and secondary curves, the fixation should be confined solely to the primary deformity.

After-treatment consists in rest in recumbency until fusion is complete, followed by the wearing of a plaster-of-Paris or block leather moulded support for at least 18 months, when normal activities without support may be resumed.

The following special forms of scoliosis require separate consideration:—

(*a*) Congenital scoliosis due to severe wedging of one or more vertebræ.

(*b*) Paralytic scoliosis which tends to relapse in spite of the most perfect correction.

(*c*) Paraplegic scoliosis.

(*d*) Sciatic scoliosis.

(*a*) Congenital Scoliosis

Scoliosis of this type is usually associated with the presence of other gross congenital deformities of bone; thus, ribs may be absent or fused; congenitally deformed vertebræ may be present at more than one site in the spine, or some other congenital abnormality—such as Sprengel's deformity or torticollis—may also be present.

From a consideration of the radiograph (Fig. 98) of such a case it is obvious that complete correction of the affected spine is impossible. The aim of treatment, therefore, should be the moulding of the growing bones into a somewhat better alignment, and this object can best be

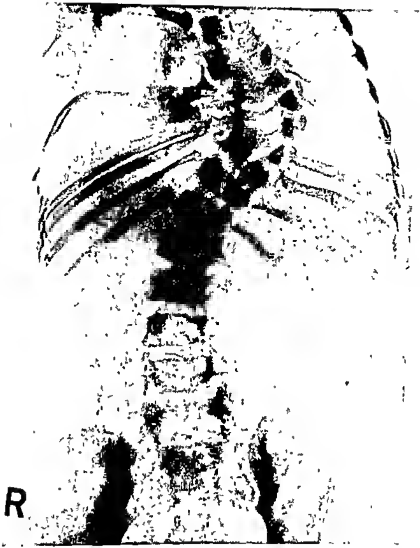


Fig 98 —Congenital Scoliosis, showing wedged vertebræ, spina bifida and deformities of ribs.

attained while the child is young and the bony tissue is still comparatively *soft.*

Corrective jackets—such as have been described—are not suitable for very young patients in whom correction is comparatively easy. At this stage the child should be placed on a *frame so that the constantly*

deforming weight of gravity is counteracted. Extension by strapping is applied to both legs, the greater pull being applied to the leg on the side of the spinal concavity. Counter-extension is applied by means of a jury mast and head band attached to the frame, and this corrective treatment is continued for at least 12 months. During this period local pressure is applied posteriorly on the convex aspect of the chest, so that the concave side tends to open out. When all possible correction has been obtained a removable cast may be applied, and by the use of this support, combined with corrective exercises, most of the correction can be maintained. It is extremely doubtful if any of the methods of bony fixation of the spine can be of help in the treatment of congenital scoliosis.

As the deformed vertebræ grow in size the spine, even when apparently soundly fused, is moulded into the shape taken by the vertebral bodies.

(b) Paralytic Scoliosis

When scoliosis has resulted from an attack of infantile paralysis the deformity of the chest and spine is usually extreme, on account of the excessive lateral deviation of the chest-wall and the severe secondary deformities of the ribs. The paralysis may affect part or all of the

(a) (b)

Fig. 99.—Paralytic Scoliosis.

erector spinæ group of muscles of one side, but, if both groups of muscles are equally affected, an acute flexion deformity rather than a lateral deviation results, as the essential feature in the development of scoliosis is retention of power in one group, which continues to act without opposition (Fig. 99). As a rule, other groups of muscles are also involved, leading to secondary deformities and disabilities. Thus, considerable shortening of one leg may be present and, because of paralysis of the intercostal or abdominal muscles, breathing may be restricted. If the intercostal muscles are paralysed and the breathing is largely diaphragmatic in character, the use of a plaster case, embracing the chest and abdomen, is inadvisable. *Correction of the deformity is*, however, possible by treatment in recumbency, correction being obtained by the use of pressure pads which can be regulated.

When the optimum correction has been obtained, fusion of the affected area of the spine is usually indicated, because of the difficulty of maintaining the position by any type of external support. The area to be fused is always extensive, involving, as a rule, 10 or 12 vertebræ, and on *account of the extent of the fusion the operation should be divided into* two stages, 5 or 6 vertebræ being fused on each occasion.

(c) Paraplegic Scoliosis

During the past few years the condition of paraplegia following on a scoliotic deformity has been recognized as a clinical entity. This complication occurs most frequently in association with acute curves of the dorsal region, and, in every instance, the apex of the deformity is formed by a wedged vertebra which is probably of the congenital type. Paraplegia is never seen in association with the more gradual deformity which is present in the acquired type of scoliosis. The first signs of pressure paralysis appear, as a rule, after 10 years of age, the child is noticed to walk with a peculiar dragging of the feet, accompanied by a slight spasticity of the legs. Following this there may be a more or less complete loss of control of the bladder, and, if not relieved by treatment, the spasticity gradually increases until walking becomes impossible. The cause of the spasticity is suggested by the long history of the deformity, by the retention of *mobility of the spine, even in the area of* greatest deformity, by the radiographic appearances, which show the absence of disease, and by the presence of a definite wedge deformity in the affected area of the spine.

Treatment

Confirmation of the diagnosis is given by the rapid response to treatment. When the patient is placed on a frame with extension applied to both legs, the paraplegia usually disappears very rapidly, and, so long as the patient is recumbent, there is no tendency to recurrence If the

patient is allowed up without an efficient support, then a reappearance of the signs of pressure on the cord is to be expected in a few weeks. Moulded plaster-of-Paris or block-leather supports are the most suitable in retaining correction, but even the most carefully moulded and fitted support will often fail in its object, and the paraplegia reappears. Under these circumstances bony fusion of the spine, by the method of Hibbs, holds out the best prospects of a permanent relief, but this method of treatment should only be adopted after all signs of pressure on the cord have disappeared, and after the optimum correction of the deformity has been obtained.

(*d*) Sciatic Scoliosis

The condition of sciatica. associated with scoliosis, occurs usually in patients between 30 and 40 years of age. Men seem to be affected slightly more frequently than women, but the difference in numbers is slight.

As a rule, the patient gives a history of pain down the back of the thigh and into the foot for some months before the curvature of the spine was noticed. Occasionally the spinal deformity develops whilst the patient is resting in bed undergoing treatment for the pre-existing sciatica, and such instances indicate clearly that the sciatica is the primary condition and that the scoliosis is secondary.

Clinical Features. The patient stands with the affected leg slightly bent at the knee. The scoliosis is largely confined to the lumbar region, and the convexity of the curve may be towards the affected leg—the so-called homolateral sciatic scoliosis—or towards the other leg—the contralateral scoliosis.

Occasionally a patient is seen in whom the position of the curve varies from one side to the other, a condition which has been described as alternating scoliosis. In this latter type the patient can change the curve from one side to the other, a movement which is only possible when the spine is fully bent. Thus, the patient may bend down with a left lumbar scoliosis and, after twisting the spine, stand erect with a right lumbar curve.

The radiographs of the pelvis and lumbar spine usually show no pathological bone change, but simply a deviation of the lumbar vertebræ to one or other side.

Etiology. The question of the origin of sciatic scoliosis has led to much discussion, the commonly held theories being:

(1) *Articular Arthritis.* This theory suggests that the condition is always caused by arthritis of the inter-articular joints of the lumbar vertebræ.

(2) *Inflammation of Nerve Roots.* It is suggested that, on account

of inflammation and swelling of the emerging nerves, the lumbar muscles develop a condition of protective spasm and thereby produce the deformity.

(3) *Irritation of Muscle.* Another suggestion is that the deformity follows on irritation and spasm of one or other ilio-psoas muscle.

(4) *Retropulsion of the Nucleus Pulposus.* The occurrence of a scoliotic deformity of the lumbar spine associated with persistent sciatica, is *always suggestive of the presence of a retropulsed nucleus pulposus.*

Treatment

As in the treatment of any type of inflammatory process, rest is essential. The patient should be confined to bed continuously for 3 weeks and all areas of possible infection dealt with radically. Traction with weight applied to the affected limb frequently hastens the recovery and diminishes the pain. If this line of treatment is successful the weight traction should be removed and the patient given gentle exercises whilst in the recumbent position. If the pain does not then return, normal activity may be resumed, preferably with the help of an adequate corset belt

If the pain persists the surgeon has at his disposal three other possibilities:

(1) Manipulation.

(2) Fixation.

(3) Operation for retropulsed disc.

Manipulation. Manipulation under anæsthesia must always be gentle, rough traction or forcing of a joint beyond its normal range can only injure and not improve the condition for which the manipulation is being employed. This rule is especially applicable in the case of sciatic scoliosis. If carried out gently the manipulation is not dangerous and will not be followed by signs of nerve or cord injury. If the manipulation is unsuccessful, one of the other methods can be employed.

Fixation. After extension of the spine by suspension the patient is fixed in a plaster-of-Paris jacket, which extends from the nipple line to the great trochanter. This fixation is retained for 3–4 months, with possibly a replacement for a similar period

Operation for Retropulsed Disc. If it is obvious that no permanent relief can be obtained by the previous methods and the examination has revealed signs of interference with the sacral plexus, as already described in Chapter XIII, the possibility of the presence of a retropulsed intervertebral disc must be considered.

Removal of an abnormal disc has in many instances cured the sciatica and the scoliosis, but the operation should only be undertaken when the surgeon is convinced of the presence of this abnormality.

CHAPTER XV

ACQUIRED DEFORMITIES

DUPUYTREN'S CONTRACTURE

In 1832 Dupuytren described a deformity of the hands characterized by flexion contracture of the fingers, due to contraction of the palmar fascia. The deformity seldom appears before middle life and almost invariably in the male sex, while occasionally evidence of a tendency to a definite hereditary influence in the deformity can be elicited.

ETIOLOGY

The cause of the deformity is unknown; rheumatism has been suggested as a common predisposing factor, while continuous heavy manual labour appears to be the exciting cause in the large majority. In some instances, however, the deformity occurs in patients who are not engaged in manual labour, appearing in clerical workers whose hands are not subjected to trauma.

SIGNS

A gradual contraction of the palmar fascia, particularly on the ulnar border of the hand, causes flexion of the metacarpophalangeal joint; at first usually the ring finger alone is involved, and later the little and middle fingers take part in the deformity. At first the fascia is simply contracted, later nodules of a hard fibrous type can be felt in its substance, while at a still later date the skin over the affected fascia becomes bound down and immobile. The flexor tendons and their sheaths remain unaltered, but, as a result of the long-continued position of flexion, the joint capsule usually becomes adaptively shortened and may offer considerable resistance to the correction of the deformity (Fig. 100).

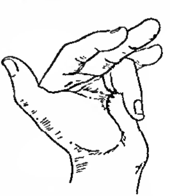


FIG. 100.—Dupuytren's Contracture chiefly affecting the Ring Finger.

Essentially the deformity consists of flexion at the metacarpophalangeal joints, while at a slightly later date the first interphalangeal joint also becomes bent, but the terminal joint is never flexed and, as a result of pressure of the finger-tip into the palm, this joint frequently develops a position of hyperextension.

Diagnosis

The diagnosis is comparatively simple, the only condition which bears a resemblance being that of congenital contraction of the finger, which involves only the little finger, and can be easily distinguished by the fact that, in contrast with Dupuytren's contraction, the metacarpophalangeal joint is hyperextended while the interphalangeal joints are *acutely flexed.*

Treatment

Preventive. In the early stages, when the contraction first appears, simple stretching of the fingers to their full extent several times a day is usually sufficient to prevent further deformity and to keep the condition in check for many years. The stretching must be complete, if the tips of the fingers are placed on a table, the hand must be forced down flat until the metacarpophalangeal joints also reach the same level.

Recently it has been suggested that in the early stages of the deformity improvement and even cure can be obtained by the administration of large doses of vitamin E. The method has not had sufficient test and may fail, as did the injection of Fibrolysin.

Operative Treatment. When the deformity is too severe to be corrected by stretching, two procedures are available—the first, consisting of multiple subcutaneous division of the contracted fascia, is simple and safe, while the second, in which the whole of the fascia is removed, although undoubtedly a sounder surgical procedure, involves the risk of the *subsequent contraction of* the skin flap.

Multiple Fasciotomy. The skin and palmar fascia are put under tension by stretching the affected fingers, the tenotomy knife is then inserted through the skin on to the surface of the fascia at a point between the deep grooves caused by adherence between the skin and fascia. The skin is then separated from the fascia in the grooves on each side, either with the back or the cutting side of the tenotomy knife, and only after this freeing *is the palmar fascia divided by turning* the edge of the knife towards the fascia and gently cutting the tightened bands. This procedure of freeing the skin and dividing the contracted fascia is carried out wherever necessary, usually in four or five different areas, and the hand and fingers are then bound to an almost straight splint, which is retained for 4 or 5 days. During this period of stretching *the greatest care must* be paid to the position of the splint. Pressure must *never be applied to the* tips of the fingers but should be limited to the palmar aspects of the terminal interphalangeal joints. If this point is neglected hyperextension and rigidity of the terminal interphalangeal joint invariably results. If, however, the pressure is applied to the front of the interphalangeal joint, no such *disability* results.

After 4 or 5 days the splint is removed two or three times each day for massage and stretching over a period of 2 weeks, and later the splint is replaced at night only for at least 3–4 months, massage, exercises and free use being carried out each day.

Excision of the Palmar Fascia. This more radical procedure is advisable when the infiltration is extensive, and where it is evident that division of the fascia alone is likely to be unsuccessful. In approaching the contracted fascia the skin incision should extend along the ulnar border of the palm down to the level of the head of the 5th metacarpal. From this point it is continued transversely across the palm. The skin outlined by this incision is raised from the underlying fascia, every effort being made to avoid puncturing or buttonholing the flap. The fascia is then divided at its upper end well above the contracted area, and carefully dissected from the underlying tissues, the greatest care being taken to avoid injury to the digital nerves which lie between its superficial and deep layers. On reaching the digital slips of the fascia these are divided, and the skin flap sewn back into position, a pressure pad of wool or sterile sponge rubber being placed over the operation field to prevent the formation of a hæmatoma. If the flap has been injured during the dissection a full thickness skin graft should be at once employed to replace the injured portion of skin. After the excision a corrective splint should be worn for a week, and the restoration of movements in the fingers obtained by voluntary use and gentle massage, which are started when the stitches are removed 2 weeks after the operation.

OBSTETRICAL PARALYSIS

That lesions of the brachial plexus may occur at birth is common knowledge, but the exact mechanics by which they are produced is still not completely understood. The muscular paralysis which accompanies these injuries follows closely on the distribution of the nerves involved, but in addition to the loss of muscle power, contractures appear rapidly round the shoulder-joint. For this reason Turner, Thomas and Lange have suggested that the early clinical signs of birth palsy and the common sequelæ are indicative of a lesion of the shoulder-joint capsule rather than of the cords of the brachial plexus. These suggestions have not been supported by operative investigation, during which definite lesions of the cords of the plexus have been demonstrated.

As a rule, birth palsy follows on prolonged and difficult labour, where extra force has been necessary in the delivery. The type of injury sustained by the plexus depends on the line of force which has produced the lesion. Thus, traction on the arm above the head may be followed by injury to the lower cords of the plexus, especially if the pull has

been so great as to produce a fracture of the clavicle. Again, traction on the head, especially if combined with a *pull towards the other shoulder*, may easily produce a lesion of the upper trunk, or in fact of the whole plexus. The extent of the injury sustained varies from a simple stretching of the fibres within the perineural sheath to a complete tear of the nerve and the sheath, or a pulling away of the roots within the spinal theca.

Site of the Lesion. Birth palsy commonly affects the upper nerves *of the brachial plexus, the more common lesion* being of the upper arm, or Erb Duchenne type. The affected nerves, the 5th and 6th cervical,

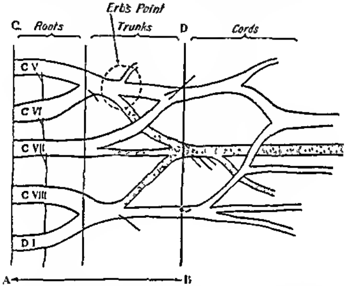


Fig. 101 — Drawing of Brachial Plexus showing Erb's point

may be injured at any level, but as a rule the lesion occurs at Erb's point, which lies at the junction between the 5th and 6th cervical nerves (Fig. 101). Occasionally no sign of macroscopic injury to the nerves can be discovered by the most careful inspection, the lesion having occurred intrathecally.

Many operative examinations of the injured plexus have been undertaken in the hope of discovering the site of injury, and if possible of effecting an end-to-end suture of the injured nerve trunks. The results of such operative procedures have been extremely disappointing, the only advantage gained from the operation being a more exact appreciation of the type of injury which has caused the paralysis.

Signs and Symptoms

These naturally vary with the site of the lesion. As a rule, in the new-born infant suffering from such an injury, the arm hangs flaccid by the side with the elbow fully extended or very slightly bent, the whole arm and forearm being rotated inwards so that the palm points backwards. Passive movements of the arm are painful to the child, who invariably cries when they are attempted. Very occasionally slight swelling may be noticed above the clavicle at the probable site of the lesion in the plexus.

Improvement in the condition of the limb is usually rapid, except in those extremely rare cases where the lesion is complete and permanent. The child begins to move some part of the arm, forearm or hand, and recovery once started is rapid, although a complete recovery is rarely, if ever, seen.

In the Upper Arm Type (Erb Duchenne Paralysis) the muscles supplied by the 5th and 6th cervical nerves lose their function. Thus, the deltoid, spinati, biceps, teres minor and brachialis anticus are all more or less completely paralysed. The opposing group of muscles, which adduct and internally rotate the arm, soon become contracted, passive abduction and external rotation of the shoulder joint being lost.

In the Whole Arm Type of Paralysis the limb is flaccid and lies at the side of the body with the elbow fully extended. As a rule, some slight improvement appears in a few weeks, but occasionally the paralysis remains unaltered with a more or less complete loss of sensation over the whole limb.

In the Lower Arm Type (Klumpke's Paralysis), in which the 1st dorsal and occasionally also the 8th and 7th cervical nerves are injured, the paralysis affects the intrinsic muscles of the hand with wasting of the thenar and hypothenar eminences, and with weakness of the long flexor muscles of the fingers. In addition, when the lesion has occurred close to the intervertebral foramina, signs of involvement of the cervical sympathetic nerves are present, and are recognized by drooping of the upper eyelid, narrowing of the palpebral fissure and contraction of the pupil.

Mixed Types. Whilst the separate clinical types already described are commonly seen, in many instances the clinical picture does not fit into any particular group. Thus, there may be the signs of an upper trunk lesion with, in addition, involvement of the flexor muscles of the forearm, or the lower arm type of paralysis may be complicated by weakness or paralysis of other muscles of the forearm—indications that the lesion has not been confined to one trunk of the plexus.

Fig 102.—Child suffering from Erb's Paralysis of the shoulder with involvement of the 7th cervical nerve in addition

Deformity. In the untreated case the greatest deformity follows on the upper arm type of paralysis. The arm becomes gradually more and more adducted and internally rotated, the forearm is fixed in pronation, while the head of the humerus may be subluxated on the posterior border of the glenoid cavity (Fig. 102) The range of passive movement in the shoulder becomes steadily diminished by contraction of the internal rotator and adductor muscles of the arm If the position of deformity is not corrected, the acromion process of the scapula may later become hooked downwards over the cavity of the shoulder, preventing the normal range of abduction of the arm (Fig. 103), while the head of the humerus becomes flattened on one side where it lies in contact with the glenoid cavity.

Treatment

The results of operations on the injured nerves of the plexus have been so unsatisfactory

Fig. 103.—Radiograph of Erb's Palsy, showing beak formation of acromion.

that treatment should consist solely in the relaxation of the paralysed muscles and the prevention of secondary contractures. Thus, in the Erb Duchenne type of paralysis, the arm should be placed in a position of abduction and external rotation. This position can be maintained by the use of a suitable abduction arm splint. The method has one grave disadvantage in the very young, as the use of the rigid frame may be followed by dislocation of the shoulder.

It is much safer not to use an abduction splint during the first 6–8 months. If the child's affected arm is tied behind the head by a bandage loop, which encloses the wrist, and is tied round the opposite shoulder, a considerable degree of abduction and external rotation is obtained. As the child grows older the abduction frame can be applied, and massage of the shoulder girdle muscles can be given without any alteration in the position of fixation. So long as improvement is occurring treatment must be continued.

Treatment of Fixed Contraction. When the early treatment has been neglected and deformity of a severe type is already present, treatment by moulding and fixation in the corrected position in a plaster case for 3 months is of value in improving the function of the limb. Occasionally the contraction is so extreme and resistant that correction cannot be obtained by simple moulding. Under these circumstances the operation suggested by Fairbank is often of considerable help, provided the joint itself is not seriously misshapen.

Fairbank's Operation. Through an incision in the line between the pectoralis major and the deltoid, the anterior part of the shoulder-joint is approached. The upper border of the tendon of the pectoralis major is incised and the subscapularis tendon defined close to its insertion. This tendon, which is the chief obstruction to the external rotation at the shoulder-joint, is then divided and any other obstructing bands released, sufficient to allow the shoulder to be placed in the corrected position. Whilst this movement is being completed, the anterior portion of the capsule of the joint is usually torn and cannot be repaired by suture. After closure of the wound the arm is fixed in the corrected position for a period of 3 or 4 days, followed by massage and passive movements. If a longer period of fixation is employed, considerable rigidity of the joint will follow and the full range of movements may be permanently lost. The operation, if carried out on patients in whom bony deformity is not yet present, results in a definite improvement in function.

Removal of Acromion. When the acromion process is seriously distorted and it is evident that the full range of movement is mechanically impossible a slight improvement may follow the removal of a portion of the process. The reason for the comparatively slight improvement is the almost invariable presence of gross deformity of the humeral head.

In the lower arm type of paralysis fixation of any type is of little help. Massage, exercises and stretching of the fingers, especially of the metacarpophalangeal range, improves the mobility and aids the activity of any muscles in which power has returned.

MYOSITIS OSSIFICANS TRAUMATICA

The development of bony tissue within the substance of a muscle occurs usually as a sequel of some localized injury, a sequence of events which has given rise to the description of the condition as a traumatic myositis ossificans in contrast with the rarer idiopathic type in which no predisposing cause can be discovered. The most common instance of traumatic myositis ossificans is seen after injuries in the region of the elbow, particularly dislocations. If a dislocation of this joint is reduced within a few hours of its occurrence, myositis ossificans is a *very rare complication, provided* that the elbow has been kept at rest for 2 or 3 weeks following reduction. If, however, an interval of several days has elapsed between the dislocation and its reduction, abnormal bone formation in the region of the joint is a comparatively common sequel, and its occurrence is almost inevitable if massage and passive movements of the joint have been employed as part of the treatment.

FIG. 104.—Myositis Ossificans of Elbow joint becoming consolidated.

Abnormal bone formation is also found occasionally after fractures in the region of the elbow-joint, the usual history being that, after a period of fixation of the joint for 1–2 weeks, massage and passive movements were employed with the object of restoring the normal joint movements, but that this form of treatment, instead of increasing movement, had been followed by a steadily increasing diminution in the range. The occurrence of this complication may be suspected from such a *history, and the diagnosis can be confirmed by the radiograph, which* shows an indefinite mass of newly formed bone lying in front of the ante-cubital fossa (Fig. 104). As a rule, the new bone is first seen on the anterior aspect of the lower end of the humerus in the substance of the brachialis anticus muscle, but on occasion all the muscles and

tendons round the joint may take part in the alteration and may form a solid bony mass, leading to complete ankylosis.

A similar type of new bone formation may occur in any muscle mass following severe bruising. The common situations for this alteration are the anterior and outer aspects of the thigh, although on occasion the rectus abdominis and calf muscles may be involved. The injury which leads to this alteration does not usually involve rupture of the skin, the subcutaneous hæmatoma gradually becoming calcified, and later ossified, the change being indicated not only by the radiograph (Fig. 105) but also by the bony resistance which develops in its substance.

FIG. 105.—Myositis Ossificans of Quadriceps Femoris becoming quiescent.

Etiology

Two suggestions have been brought forward to explain the development of this abnormal bony tissue.

1. That it results from tearing of the periosteum and release of bone cells which pass into the neighbouring muscle. This theory might easily explain those instances of myositis ossificans round the elbow, but could not explain the development of bone in the substance of a muscle completely separated by normal tissue from the nearest bone.

2. That the formation of the abnormal bony masses is an instance of metaplasia, such instances of conversion from one tissue to another being comparatively frequent in other parts of the body.

Treatment

Although it may be impossible to prevent the formation of bone after bruising of the thigh or the abdominal wall, the extent of the alteration may be controlled by complete rest of the area involved and by the absence of all forms of active treatment, such as massage

or passive movements, at any period. Fortunately the more common development in the region of the elbow-joint can usually be prevented by intelligent treatment.

After the reduction of a dislocation of the elbow-joint, particularly if there has been an interval between the accident and the reduction, rest of the joint for at least 3 weeks should be insisted upon. After that period active movements are permissible, so long as this activity is followed by an increased range of movement. If, however, the resumption of active movements is followed by a diminution in the range, then

FIG 106.—Myositis Ossificans of the Elbow, progress of the disease has been arrested

further rest is indicated. No massage or passive movements are advisable at any stage, and an almost identical routine should be followed in the case of fracture in the same neighbourhood Fixation of the broken bone for 3 weeks should be followed by active movements of the joint, and if this course is followed consistently, the formation of myositis ossificans in the region of the elbow will be a very rare phenomenon

If, however, the change has already occurred and a bony mass is already present, complete rest of the joint must be instituted immediately. Radiographs should then be taken at intervals of 4 weeks, and immobilization must be continued until it is obvious that the new bony tissue is diminishing in size and is becoming smooth and rounded

Fig. 106). The growth, which at first is indefinite in outline, gradually becomes more defined and diminishes in size, and even when it does not entirely disappear its presence usually leads to little or no inconvenience. If, on account of its size, the bony mass interferes with the function of the joint, its removal may occasionally be advisable at a much later date.

When myositis ossificans has developed in the muscles of the thigh, rest of the affected area must be instituted immediately. As these muscles govern the movements of the knee-joint, they can be effectively rested by preventing movement at this joint by the use of a long back splint. While wearing this the patient may be allowed to walk about, as the movements of the hip-joint affect the thigh muscles only to a very slight degree. The fixation must be continued until the new bone has been absorbed, or until it is localized as a rounded bony mass which is gradually diminishing in size. As in the case of the elbow, no passive movements or massage should be used at any stage of the treatment, and, as a rule, removal of any remaining portion of new bony tissue is unnecessary.

VOLKMANN'S ISCHÆMIC CONTRACTURE

This crippling deformity was originally described in 1875 by Volkmann as a contracture of the fingers and wrist which was caused, in his opinion, by tight bandaging, following injuries about the elbow-joint. It is seen most frequently in children following injuries to the elbow or to the bones of the forearm, usually but not invariably after the commencement of treatment. It may, however, occur following an injury in the neighbourhood of the elbow in a patient who has had no treatment of any kind, a circumstance which disproves the statement that Volkmann's Ischæmia is always the result of the surgeon's negligence.

Etiology

Most frequently the condition follows on a supracondylar fracture of the humerus, where an attempt has been made to fix the fracture by acute flexion of the elbow-joint beyond the limit of safety, and on occasions it appears after the fixation of a fracture of both bones of the forearm in splints or plaster of Paris.

Until recently it has been generally accepted that the fibrosis and contracture of Volkmann's Ischæmia resulted from interference with the return of blood from the flexor muscles. This opinion was supported by the experimental work of Brooks and Jepson, who, working on dogs, found that ligature of the main artery to a limb caused a massive necrosis

of muscle without contraction. If, however, the lumen of the artery was preserved, while that of the accompanying vein was destroyed, a typical, though somewhat temporary, contraction appeared in the affected muscles.

Middleton has shown that the veins from the flexor muscles of the forearm converge into one main trunk in the antecubital fossa, an arrangement predisposing to obstruction following acute flexion of the elbow, or the development of a hæmatoma in this region.

Recently Griffiths has demonstrated that Volkmann's contracture can follow directly on injury to the brachial artery in the antecubital fossa, in the complete absence of any sign of venous obstruction or hæmatoma formation. The artery shows signs of widespread spasm of its wall, the lumen being constricted over a wide area, the arterial spasm affecting not only the brachial artery itself, but also its ulnar and radial branches. Relief of the spasm was obtained by arterioectomy, in which a complete section of the artery was removed between ligatures. During the operation the greatest care was taken to prevent injury to the delicate collateral vessels, on which the blood supply of the forearm depends.

Pathology

Some of the fibres of the affected muscles remain more or less normal in size and staining reaction, but most show loss of the nuclei of the sarcolemma with increase of the interfibrillary fibrous tissue. The transverse striation of the fibres is lost, and in places the normal striation has disappeared, the individual fibres being converted into a granular mass of structureless tissue containing many cells, showing in a few places traces of transverse striation. Small round-celled infiltration is widespread, these cells exerting a phagocytic action on the degenerated muscle fibres, and later being replaced by fibroblasts and new fibrous tissue.

Symptoms

In a typical onset the patient complains of severe pain in the hand and fingers within a few hours of the original injury, or of the reduction of a fracture, but unfortunately the value of this most important sign of the onset of trouble may be entirely lost when the patient is a young child and is not able to explain the cause of the discomfort. The hand rapidly becomes swollen, the fingers gradually flex, whilst there is a gradually increasing loss of power of voluntary movements. Slowly the swelling in the hand disappears, the fingers become more contracted, and the flexor muscles of the forearm are felt to be hard and fibrotic, while, in addition to the loss of voluntary movements of the wrist and fingers, passive dorsiflexion is also lost at these joints. The process may be arrested at any stage, so that eventually there may be any

degree of deformity from a slight limitation of full extension of the fingers and wrist to the fully formed typical contraction as seen in Fig. 107.

FIG. 107.—Volkmann's Ischæmia, showing flexion of wrist and interphalangeal joints with hyperextension at metacarpophalangeal joints.

Clinical Picture

Many instances of a mild type of Volkmann's contracture are seen following injuries in the region of the elbow. The only abnormality may be an inability to dorsiflex the wrist and fingers, either actively or passively. The fingers themselves may appear to be unchanged, but the muscles of the flexor aspect of the forearm are always more resistant, whilst the strength of the hand and fingers varies little from the normal.

In the severe type of deformity the forearm is thin as compared with the normal; the wrist is flexed, whilst the fingers are straight or slightly over-extended at the metacarpophalangeal joints, and acutely flexed at each of the interphalangeal joints. The forearm is fixed in full pronation, and active or even passive supination is impossible. The fingers and thumb are usually white and have lost most of the pad from their tips, while occasionally definite ulceration may be present, especially in cold weather.

Loss of Sensation. Some diminution in sensation is also invariably present over the fingers and thumb. Occasionally the loss of sensation over the area supplied by the median or ulnar nerve may be complete owing to an anatomical division of the affected nerve at the site of injury. As a rule, the loss is only partial and is the result of fibrosis in and around the median and ulnar nerves, consequent on the interference with their normal blood supply.

Treatment

Prophylaxis. As the ischæmia in most cases follows the reduction and fixation of a supracondylar fracture of the humerus, or of a fracture of the bones of the forearm in a child, it should be an invariable rule

that, after the reduction—which must be completed with the utmost gentleness—the arm must always be examined in 4–6 hours.

Preventive Treatment. The prevention of this deformity is much simpler than its correction, and the surgeon who appreciates the danger of its occurrence is not likely to meet with it often in his own practice.

In supracondylar fracture of the humerus, with the usual displacement of the lower fragment backwards, reduction of the displacement does not follow simple flexion of the elbow. The displacement must first be reduced and the position of flexion of the joint used simply as a method of retention of the fracture. The position of flexion at which the elbow is to be *maintained should never be the* most acute angle possible at the joint. The surgeon must always make certain that he can passively flex the elbow at least another 5–10 degrees from the position at which he proposes to fix the joint by bandage or strapping.

Similarly, in the case of fracture of the bones of the forearm, retentive splints or the plaster-of-Paris case must be applied so that the normal circulation is not interrupted. If there are signs of the development of contracture, any obstruction to free circulation must be removed. Thus, with a fracture of the forearm the splints or plaster case should be taken off, whilst in the case of a supracondylar fracture, which is fixed in flexion, strapping or bandages are removed and the elbow brought to right angles. This relief of pressure alone is usually sufficient to prevent any further progress of the condition, and if these details are attended to more radical procedures are seldom necessary.

If these simple mechanical measures are not sufficient to stop the progress of the deformity, valuable time must not be lost. The region of the antecubital fossa should be explored, and the arterial and venous system there inspected. A mechanical obstruction, in the shape of a displaced fragment of bone, if present, should be dealt with by reduction, and a severe arterial spasm should be treated by altering the position or by exsection.

It is as yet undecided whether in every case of arterial spasm exsection of the affected portion of the artery is necessary. In several instances, by altering the position of the limb, the spasm has apparently been relieved, and signs of contraction have disappeared.

Mechanical Treatment of the Severe Type. Of the many methods advocated for the treatment of the fully established deformity, the method of stretching the contracted muscles by splintage, as advised by Robert Jones, has proved itself to be the most successful. The method is simple and depends on the stretching of the contracted muscles. As dorsiflexion of the wrist causes increased flexion of the fingers, the wrist is first flexed so that the fingers are fully extended. *Finger splints are* now applied in this position, and after continued stretching for days, or weeks, it is found possible to apply a straight splint on the palm and

fingers, the finger splints being also retained. Continued stretching by means of this splint results in the wrist and fingers being brought almost into line with the forearm, when a straight splint may be applied. Eventually the wrist is brought to a position of slight dorsiflexion, after which the splints may be removed for massage and exercises, and are for some weeks replaced at night in order to prevent a recurrence of the deformity. It is very important to remember that, during the whole course of stretching, the finger splints should be maintained in position, as their presence allows pressure to be applied over a wider area, and so prevents the pressure sores which would otherwise form on the finger-tips.

An improvement in the appearance of the hand can also be obtained by the operation of muscle sliding, described by Max Page, in which the internal epicondyle is detached from the humerus, and, after division of the flexor muscle origin to the ulna, the detached condyle is slid downwards, to be reattached to the inner border of the ulna about 1–2 inches lower down, thus providing a shorter course for the contracted muscles, and allowing the fingers and wrist to be brought to the horizontal plane, or even into dorsiflexion.

It is important to realize that, in both these forms of treatment, the improvement in the appearance and function is largely due to an alteration in the position of the hand and wrist. If no voluntary movement is present in the flexed position of the hand and fingers, it is improbable that any active movements will be possible after correction of the deformity. This is especially so following the open operation, which simply results in alteration of the angle of action of any functioning muscle fibres, and not in any increase in the range of movement.

The method of gradual stretching of the fingers leads to a lengthening of the fibrous and remaining active tissue, and a successful correction of the deformity by this line of treatment is usually followed by slight increase in the range of active movement in the new position.

The operations of lengthening the tendons of the contracted muscles, of excision of the carpus and shortening the radius and ulna, have been abandoned on account of the consistently poor results which follow their use.

TORTICOLLIS

Torticollis, or wry neck, a deformity of the cervical spine, may be present at birth or may make its appearance at any later period.

SIGNS

In its typical form the head is tilted over to one side, whilst the chin points upward and towards the other side. The sternomastoid

muscle on the concave aspect can be felt as a contracted firm band, in which either the sternal or clavicular head may appear to be alone involved in the contraction. Careful examination will usually show that, whilst one head of the muscle may be more prominent than the other, both are taking part in the contraction (Fig 108).

Clinical Types

1. Essential or Primary Torticollis.
2. Secondary Torticollis.

Primary Torticollis, or the deformity which is caused by an alteration *in the structure of the sternomastoid*, may be present as a definite deformity at birth, or may not make its appearance until as late as the tenth year of life

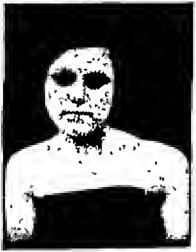


Fig 108—Torticollis

Pathology. Examination of the contracted muscle reveals a fibrotic infiltration of the muscle, which is not so long nor so large as the corresponding muscle on the other side of the neck. Patches of fibrous tissue are distributed between the muscle fibres, which are thereby diminished in size and number. Secondary adaptive changes in the soft tissue follow, thus, the cervical fascia on the affected side is shortened, curvature of the cervical spine develops, and a definite asymmetry of the face can be recognized in the older children. This asymmetry would appear to be solely the result of the position of deformity, as a similar hemiatrophy is seen after prolonged fixation of the head from any other cause, such as cervical tuberculosis.

Double Torticollis. Occasionally both sternomastoid muscles are contracted, producing a peculiar deformity of the head and neck, the *shoulders are high, the head is held forward* and both muscles are prominent.

Etiology The exact etiology is obscure. Many children at birth present a definite tumour over the middle of one of the sternomastoid muscles. This seems to give a simple explanation of the development of torticollis—a rupture of the sternomastoid muscles, development of a hæmatoma over the site of rupture and subsequent contraction of the fibrous mass. Unfortunately such a simple explanation cannot entirely

explain the condition, because, after rupture of a muscle, stretching rather than contraction is the invariable rule, and secondly, several of these so-called sternomastoid hæmatomata have been dissected and have been shown to contain little or no blood, the lump being caused by a localized œdema. It is, however, possible that, if the sternomastoid muscle is already contracted before birth, stretching of the contracted muscle at birth may lead to the formation of a super-added hæmatoma.

It appears that the deformity results from the occurrence in the affected muscle of a process similar to that occurring in Volkmann's contracture, and it is suggested that the scattered fibrosis of the sternomastoid muscle results from an interference with the circulation in the muscle, the fibres gradually becoming shorter, leading to contraction with consequent deformity of the head. This contraction of the muscle may be present as a fully developed deformity at birth, producing a so-called congenital torticollis, or it may gradually increase from a very slight shortening leading to the appearance of the deformity at a later date.

Secondary Torticollis. This group contains all the other conditions of bony abnormalities or pathological changes which lead to the development of a lateral deviation of the cervical spine with a secondary contraction of the muscle. Included in the group are:

1. Bony abnormalities of the cervical vertebræ.
2. Irritative conditions of the cervical region (inflamed glands, etc.), producing spasm of the sternomastoid.
3. Tuberculous or other disease of the cervical spine.
4. Ocular abnormalities.
5. Spasmodic torticollis.

Differential Diagnosis

As a rule, there is little difficulty in determining the cause of the lateral deviation, the cervical spine being mobile in all directions except that in which it is opposed by the contracted muscle. Occasionally difficulty is experienced in differentiating between torticollis and Pott's disease of the cervical spine. In the early stages of this disease little help can be obtained from the radiographic appearance of the cervical spine, even the most careful examination may fail to detect any bony abnormality. The diagnosis at this early stage is often made on the clinical examination alone; when movements of the neck are attempted, even in the earliest stage of the disease, all the cervical muscles become contracted and all movement is resisted, while with torticollis, all movements are free and unrestricted except that opposed by the contracted sternomastoid muscles. One clinical observation is frequently of help in the differential diagnosis. In torticollis the chin is twisted away from the contracted sternomastoid muscle, whilst in Pott's disease the chin points towards the contracted muscle.

Inflamed Cervical Glands. These are usually distinct and painful and give little trouble in diagnosis.

The other conditions which produce a secondary torticollis usually cause little trouble in diagnosis, and a careful examination of the patient will demonstrate their presence.

Treatment of Torticollis

Non-operative. Mild cases which come for treatment early can be dealt with adequately by manual stretching of the contracted structures, combined with massage of the muscle tumour. This treatment is carried on several times daily for at least 3 months, or until all signs of the deformity have disappeared. The mother, or nurse, should be instructed to carry the child on the arm so that, as the head falls inwards, the contracted muscle is stretched.

Operative. When it is evident that manipulative treatment is inadequate, or after the attempt at cure by manipulation has failed, open operation should be undertaken. There is one important clinical point to remember before operation for torticollis on any child over 3 years of age. Always demonstrate to the parents that the face is not symmetrical, as this want of symmetry becomes more apparent after correction of the deformity, and it may be suggested that the operation has produced the atrophy of one side of the face and skull

Open Operation. Through an incision 1 inch long, extending obliquely upwards and outwards from the inner end of the clavicle, the two heads of the muscle are defined and divided close to their bony attachments. After the division the rotation of the head is only slightly improved, on account of the contraction of the deep cervical fascia, this is then put under tension and divided until free rotation and abduction are possible. Following the complete operation in a child under the age of 4 years, no form of rigid corrective retention is necessary, the child's head being placed in the corrected position between sandbags until the removal of the stitches. Exercises are subsequently continued for at least 2–3 months, and during this time it will be noticed that the facial asymmetry gradually disappears.

If the patient is over 5 years at the time of operation a plaster-of-Paris corrective cast may be retained for at least 2–3 weeks after the operation.

Tenotomy. It is claimed that a successful result can be obtained by tenotomy of the sternomastoid, and that this method of treatment is preferable because of the absence of the operation scar. Its use, however, has all the disadvantages of an incomplete operation, as the deep fascia, which is equally at fault, cannot be divided on account of danger to the underlying vessels and nerves. As the operation is

only partial, prolonged after-treatment is essential, and for various economic reasons adequate after-treatment may be impossible.

Division of the Upper Attachment. When the patient is a female it may be difficult to persuade the parents that the small scar of operation over the lower attachment of the muscle will soon disappear and leave only a slight mark. Under these circumstances it may be considered justifiable to detach the upper end of the muscle from the mastoid process the subsequent scar being then covered by the hair. This procedure is technically more difficult and complete division of the deep fascia is usually impossible.

SPASMODIC TORTICOLLIS

This variety of secondary torticollis differs from all others in its mode of origin, clinical signs and treatment. Adults only are affected, and usually only those who are subject to mental strain, or those engaged in very delicate manual labour, the ordinary outdoor worker never being affected.

Signs and Symptoms

The first complaint is usually one of intermittent stiffness in the back of the neck. This gradually alters in character, and intermittent muscle spasms develop in the cervical muscles which tilt the head laterally. At first, deviation of the head may be prevented by a strong voluntary muscular effort, but gradually this power of control is lost and the recurring deformity becomes increasingly frequent. The first muscles taking part in the spasm are the sternomastoid muscle of one side and the posterior cervical muscles of the opposite side. In the absence of successful treatment this clonic muscular spasm tends to spread and may affect the muscles of the face, arm or spine, so that on each recurrence of the spasm the patient may be turned round or almost lifted from a chair.

Prognosis

If treated efficiently and in the comparatively early stages the prognosis is good, but if the condition has been present for many years, and if the spasm has spread to other areas, little can be done to improve it.

Treatment

Any local condition, such as carious teeth, infected tonsils, or defects of vision, which might possibly cause or increase the nervous irritability, should be attended to before direct treatment is instigated. Following this the patient should be taken away from all work and worry for at least 6 months. It is advisable that this period of rest should be spent

in the country away from all distractions and amusements, and complete bodily and mental rest should be the aim of treatment.

Locally, all movements of the head must be prevented by the wearing of a collar, the most suitable being a moulded block-leather collar, which extends over both shoulders and under the occiput and chin so that movements are efficiently controlled (Fig. 109). The ordinary low type of collar cannot possibly be effective in controlling the spasms and its use must always result in failure.

The collar should preferably be of moulded firm leather, as the use of the slightly more efficient plaster-of-Paris case is usually followed by pressure sores The collar, which is carefully removed once per day for washing the skin, is worn day and night, and, whilst it may add to

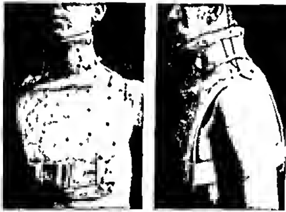


FIG. 109 —Moulded Leather Collar for the treatment of Spasmodic Torticollis

the patient's discomfort for the first 6–8 weeks, continuation of the treatment results, in the large majority of cases, in complete cessation of the spasm and in relief of the patient.

No other form of treatment, such as massage or electrical stimulation, is necessary or advisable, as their use can only lead to a reappearance of the spasm and recurrence of the deformity.

Operative Treatment. In the operative treatment of this condition the sensory and motor roots of the 1st, 2nd and 3rd cervical nerves on the affected side are divided, either after their emergence from the spinal canal, or close to the cord after laminectomy. In addition to this the spinal accessory nerve is also divided on the opposite side in the hope of eliminating all the spasm. The results of these very elaborate surgical procedures are so invariably disappointing that they should never be undertaken.

CHAPTER XVI

THE FOOT

In its structure the foot has been very aptly described as a hemisection of a dome, its highest point being the astragalus through which the body weight is transferred from the leg to the tarsal and metatarsal bones. At each of the tarsal and tarsometatarsal joints the ligaments which support and bind the bones together vary in strength, according to their position and the amount of strain to which they are subjected, those on the dorsum, which do not normally bear strain, being weak, while those on the plantar aspect are particularly strong.

With a normal arch and the foot in the neutral position, most of the body weight falls in the line of the second metatarsal, being borne posteriorly through the os calcis and anteriorly through the heads of all the metatarsals, particularly the 1st, 2nd and 5th. In the normal foot weight is borne along the whole extent of its outer border, while on the inner aspect there is no direct contact between the sole and the ground, the weight passing through this section of the tarsus and being supported by muscles and plantar ligaments. In its bony arrangements the outer border of the foot is mechanically more stable than the inner, the articular surfaces of the calcaneo-cuboid joint being wide and flat, and firmly supported by their position in contact with the ground, while on the inner side of the foot there is no articulation between the sustentaculum tali of the os calcis and the scaphoid. In this interval the under surface of the head of the astragalus rests on the strong calcaneo-scaphoid ligament, which fills in the gap, the point of contact between the ligament and the bone being indicated on the surface of the head of the astragalus by a special articular facet. This mechanical arrangement of the foot, by which its outer border is supported on the ground while the inner aspect or arch is raised, permits the movements which take place in the tarsal and tarsometatarsal joints in response to variations of pressure and strain.

There are two chief factors in the support of the arch :

1. The muscles of the leg and foot which, by their contractions, support the arch and prevent the strain of body weight being borne directly and solely on the ligaments of the foot.

2. A series of complicated ligaments of different strengths extending between the adjacent tarsal and metatarsal bones and between the tibia and fibula and some of the tarsal bones.

No ligament, however strong, can indefinitely resist the strain of weight-bearing, and, unless adequately protected against this force, the ligaments of the foot gradually stretch and the deformity of flat foot appears.

Muscles

Most of the muscles below the knee take part in the support of the arches of the foot. Thus, the short intrinsic muscles of the foot—the flexor brevis digitorum, accessorius, abductor minimi digiti and abductor hallucis—are of great importance in maintaining the normal position of the tarsal bones. They arise from the os calcis and are inserted into the base of the proximal phalanges of their respective toes. In their contractions these muscles perform not only their particular function of flexing or abducting the phalanges into which they are inserted, but they also tend to approximate the anterior to the posterior part of the foot, thereby raising the arch and preventing its collapse. Most of the muscles which arise in the leg and are inserted into the foot in front of the ankle-joint act more or less as arch supporters, but certain of them are of special importance. The tibialis posticus, passing into the sole from the inner side, is inserted into the plantar aspect of the tarsus, being attached to every tarsal bone with the exception of the astragalus, and also into the bases of the 2nd, 3rd and 4th metatarsals. The peroneus longus, passing into the sole round the cuboid from the outer side, is inserted into the base of the 1st metatarsal *These two muscles, through their tendons,* act as a definite suspensory strut, which on contraction tends to prop up the mid-tarsal area and allows the front and back of the foot to fall away. Likewise, the tibialis anticus muscle, whose tendon is inserted into the inner side of the scaphoid and cuneiform, lifts the inner border of the tarsus and so maintains the greater height of the arch on this aspect.

The flexor longus hallucis and the flexor longus digitorum muscles also help in maintaining the arch; by approximating the toes to the heel they increase the height of the arch and by their contraction support it, especially when the other suspensory muscles are yielding through weakness or overstrain The flexor longus hallucis tendon enters the sole behind the internal malleolus, passes along the inner side of the tarsus and is inserted into the base of the terminal phalanx of the great toe, which, in the normal foot, lies in the direct line of the 1st metatarsal. With the great toe in the normal position the support given by its long flexor muscle is of considerable importance to the inner side of the foot, but if *the toe is deviated to any considerable degree*, as occurs in hallux valgus, the tendon cannot act to advantage and, with a loss of its supporting action, the strain on the other muscles is increased.

So long as these muscles of the leg and foot are sufficiently powerful or are not overused symptoms of foot strain do not appear, but if, because of excessive weight or loss of muscle tone through illness or fatigue of the muscles, this function of weight-bearing cannot be carried out, signs and symptoms of foot strain develop rapidly.

Ligaments

The tarsal and metatarsal bones are joined together by ligaments which pass between the neighbouring bones on their dorsal and plantar aspects. Those on the dorsal or convex aspect are subjected to a minimum of strain and are, therefore, comparatively weak, while those on the plantar aspect, whose function is the retention of the normal relation between the bones of the foot, are subjected to great strain, and, in consequence, are strongly developed. They are not, however, of equal strength all over the foot, but are especially developed on the inner side where the greatest strain is borne.

The inferior calcaneo-scaphoid or spring ligament, which joins the under surfaces of the os calcis and scaphoid, is the thickest, strongest and most important ligament in the sole of the foot. It extends between the sustentaculum tali of the os calcis behind to the under and inner side of the scaphoid in front, and on its upper surface it directly supports a small area of the under surface of the head of the astragalus. The outer border of the foot is supported by the long and short plantar ligaments, which extend between the lower surfaces of the os calcis and cuboid. The fan-shaped internal lateral or deltoid ligament of the ankle-joint lies on the inner aspect, attached by its narrow end superiorly to the internal malleolus, while inferiorly it spreads out to be attached to the os calcis, calcaneo-scaphoid ligament and scaphoid. While not comparable in strength with the spring ligament, it is of the very greatest importance in maintaining the normal alignment of the foot. It prevents eversion, and by its attachment to the medial side of the scaphoid limits abduction of the fore part of the foot, which is the usual beginning of deformity.

The plantar fascia, from its narrow attachment to the tuberosity of the os calcis, spreads out as it passes forwards to end in five slips, which are attached to either side of the metatarsophalangeal joints and to the base of the first phalanx of each toe. This strong fascia has two functions; firstly, it helps to retain the arch—as the string maintains the shape of the bow—and secondly, it protects the muscles, vessels and nerves which lie under its cover from the constant injuries to which they would be subjected in walking.

STATIC DEFORMITIES OF THE FOOT

Everted Foot and Flat Foot

These two deformities, although frequently occurring together, are in reality distinct and separate clinical conditions which differ in prognosis and in treatment. When a child stands for the first time the whole of the sole of the foot comes in contact with the floor. There is apparently no arch present on the inner side of the foot, although on examination it is evident that the tarsal bones on the inner side are at a higher level than

along the outer border. This appearance of complete flat foot in young children, which can be considered normal, is caused by the presence of an abnormally large deposit of fat, combined with the lack of experience in the method of using the calf muscles to lift the inner side of the tarsus. Soon after commencing to walk the apparent flat foot disappears, the raising of the inner side of the tarsus becomes obvious and the normal movements of the foot at each of its constituent joints leads to an improvement in walking, and to the normal spring reaction in the foot itself.

Everted Foot

Although occurring also in adults, eversion, or pronation of the foot as a single deformity, is commonly seen in young children in whom the laxity of the internal lateral ligament has permitted the foot to roll outwards from its normal position below the tibia. As a consequence, the line of strain of weight-bearing has changed from its normal position along the 2nd to the 1st metatarsal, or even to a point on the tibial side of this bone. *In these young children a simple eversion of this kind causes little or no discomfort, the child usually being seen because the parents have noticed* the deformity of the foot, or the abnormal prominence of the internal malleolus. Associated with the eversion of the foot there is often a considerable degree of genu valgum which still further increases the appearance of deformity and leads to the mistaken diagnosis of flat foot

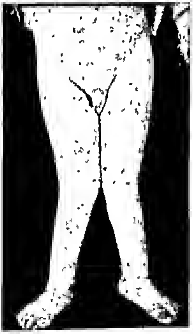


Fig. 110.—Mobile Flat Foot associated with Knock-knee.

On examining such a foot it will be found that when the strain of weight-bearing is removed the normal alignment of the foot and leg is restored and it is evident that there is no real falling of the longitudinal arch, although increased mobility is present at the ankle-joint In spite of the eversion of the foot and the genu valgum, these children often stand and walk with the toes turned inwards, in an unconscious effort to correct the deformity and to throw the weight on the middle or outer border of the foot Unfortunately this turning in of the toes is usually considered by the mother or nurse to be a deformity, and the child is constantly corrected and told to turn the toes outwards. If a

child suffering from simple eversion of the foot, with possibly some genu valgum (Fig. 110) and no other demonstrable deformity, continues to walk with the toes turned inwards, then this method of walking should be encouraged. The so-called deformity of inturned toes will disappear as soon as the necessity for it—namely, the eversion of the foot and the genu valgum—has been corrected. If the child does not already walk in this manner, treatment should consist in the application of a Thomas heel to the child's shoe. The alteration here consists in raising the inner border of the heel of the shoe one-sixth of an inch and continuing the heel half an inch forward on the inner side, so that on standing the body-weight is *borne more on the outer border of the shoe*—an alteration which tends to rotate the foot inward. These alterations must be maintained so long as the deformity is present and should only be removed when the legs and feet return to normal.

Flat Foot and Foot Strain. Pes valgus, or flat foot, is the term used to describe the wide variety of types of deformity in which the common factor is the falling of the inner longitudinal arch of the foot. The falling may or may not be associated with pain, and in some instances the change from a normal foot to a condition of complete flattening of the arch takes place without causing any discomfort or disability to the patient. As a rule, the patient complains of pain during the whole course of the alteration of position, the pain being usually associated with tenderness on the inner border of the foot, and with pain or aching up the leg on both aspects of the tibia along the stretched tibialis anticus and tibialis posticus muscles, which normally support the arch. The cause of this failure in support can be found in an inequality between the strength of the supporting muscles and the work they have to perform. Thus, increasing weight of the patient, excessive strain through long-continued standing or marching, or temporary muscle weakness following illness, may each lead to failure of the normal muscular mechanism. Similarly, badly fitting shoes may prevent the normal action of the short muscles of the sole which normally have a considerable supporting value.

As a result of one or more of these factors, the ligaments of the foot are subjected to an abnormal and continued strain which is naturally greater on the inner aspect of the foot. Continuation of the strain eventually causes a lengthening of all the ligaments, particularly of the internal lateral and the calcaneo-scaphoid ligaments, which are the most important factors in maintaining the normal bony relationships. As these ligaments stretch, the space between the sustentaculum tali and the scaphoid is increased, the head of the astragalus falls downwards and the shape of the foot on the inner side is altered from a concave to a convex outline. The falling of the arch and stretching of the ligaments is accompanied by tenderness over the whole of the inner side of the foot, but particularly under the tubercule of the scaphoid, the point of attachment of the

calcaneo-scaphoid and internal lateral ligaments. The pain and disability which follow falling of the arch depend to a large extent on the rate at which this has occurred; thus, a gradual yielding, extending over a period of years, is usually a comparatively painless process, while an acute yielding generally causes severe pain.

Rapid falling of the arch commonly follows excessive and unaccustomed use of the feet; as an example, an army recruit taken from a sedentary occupation has to march ten or even twelve miles, an effort which is beyond his strength. Because of the sudden and severe strain on the feet the ligaments are stretched, the feet are acutely painful and show considerable œdematous swelling, which disappears after rest in bed, but reappears the next day on any further attempt at marching. This condition of acute foot strain can be recognized by the severity of the tenderness, swelling and spasm of the overstretched muscles, the whole condition returning to normal if sufficient rest is provided together with physiotherapy to improve the circulation.

At first, as the arch falls the normal position of the foot can be readily restored by the patient removing the weight-bearing strain from his feet. Later, with long-continued stretching of the ligaments, adhesions develop at the insertion of the ligaments into the bones, limiting the mobility of the foot in every direction It is evident then that feet which were at first mobile can become rigid owing to ligamentous stretching and the formation of adhesions.

Classification

In order to appreciate the development of the deformity and the most suitable method of treatment which should be employed in its correction, it is advisable to sub-divide flat feet into the following groups:

(a) Congenital.

(b) Acquired $\begin{cases}\text{Mobile.}\\ \text{Rigid.}\end{cases}$

(a) Congenital Flat Foot

The congenital type of flat foot forms a comparatively small group, and the deformity is usually discovered soon after birth. Owing to the arrangement of the tarsal bones in this type of flat foot the sole of the foot appears to be convex, the apex of the promontory being caused by the presence of the head of the astragalus on the under surface. From this prominence in the middle the sole rises at either end, both the heel and the ball of the foot being at a higher level than the middle. The calf muscles become contracted, preventing the descent of the heel, and maintaining the convex position of the sole of the foot at every angle of plantar or dorsiflexion. Passively, it is impossible without very considerable force to restore the arch, the extensor tendons of the toes standing out firmly

when an attempt is made to invert and adduct the foot at the mid-tarsal region. The radiograph shows the tibia articulating with the posterior part of the upper surface of the astragalus, while the body and head of the bone are pointing into the sole (Fig. 111). The head of the astragalus

FIG. 111.—Congenital Flat Foot showing astragalus pointing downwards, normal foot above it

can be seen to lie at the same or a slightly lower level than the lower surface of the os calcis and scaphoid, whilst the posterior articular surface of the scaphoid, which normally articulates with the head of the astragalus, now lies in contact with the dorsum of the bone.

Treatment of Congenital Flat Foot

If treatment is begun in the first few months of life some improvement in the shape and function of the foot can be expected; although the restoration of a normal appearance is generally impossible, yet function is good, and the later development of bursæ and callosities is prevented.

The correction of the deformity is always difficult. The foot must be moulded under anæsthesia until the anterior portion has been brought more or less into line with the posterior segment. This moulding, however efficient, must be repeated on several occasions, the foot in the intervals

being fixed in the corrected position in a plaster cast. In the final moulding the arch is restored as completely as possible, and the foot is fixed in the corrected position about 15–20 degrees above right angles, the tendo achillis having been lengthened by a Z-shaped division. Finally the muscles are developed by exercises and by the alteration of the line of body-weight when the child begins to walk (Figs. 4 and 5).

If treatment has been neglected and callosities have already formed on the sole under the head of the astragalus, then complete correction of the deformity is impossible. Improvement can, however, still be obtained; the foot should be moulded as before until no further improvement is possible, the tendo achillis and the posterior part of the capsule of the ankle-joint being stretched or divided. If long-continued moulding has failed, and there is still a definite boat-shaped deformity of the sole of the foot causing disability and pain, then an operation for removal of the head and neck of the astragalus, followed by corrective moulding, affords the best chance of relief.

The operation is carried out through a dorsal incision, the extensor tendons being pulled inwards, the neck of the astragalus divided, and the head of the bone removed. After this the foot is moulded into concavity, but, if this is impossible, it may be necessary to perform an osteotomy of the anterior portion of the os calcis, when correction becomes simple. Fixation in the corrected position in a plaster case for 8 weeks, followed by the wearing of suitable shoes and regulated exercises, leads to a steady improvement. The result of the operation is usually an improvement in the shape and appearance of the foot with little alteration in its mobility.

(b) Acquired Flat Foot

Excluding the very small group of congenital deformities, all other types of flat feet are acquired. As the deformity is caused by a want of proportion between body-weight and the supporting muscles of the foot, the deformity naturally occurs commonly at two distinct periods of the life cycle; the first in children who have grown rapidly and in whom the muscle power has not increased in proportion with the height and weight of the body, and, secondly, in middle and later life, when there has been a definite and steady increase in body-weight without any compensatory increase in muscle power.

Symptoms. Although occasionally the deformity appears without causing pain or discomfort, yet such a history is the exception. As a rule, the patient complains of aching and tenderness in the foot before any definite falling of the arch can be demonstrated clinically. The usual story is that the foot feels tired and aches all over, more especially on its inner border, where tenderness can be elicited by pressure on the tubercle of the scaphoid. At this spot, the internal lateral ligament of the ankle

and the spring ligament of the foot are both attached with a definite intermingling of their fibres, and true falling of the arch cannot occur without stretching of both ligaments. Following continued strain the internal lateral ligament may be tender, especially along its anterior border, and the sense of discomfort and even tenderness may extend up both sides of the tibia along the course of the tibialis anticus and posticus muscles. In addition, tenderness may be present under the tip of the external malleolus. These symptoms are present at first only during weight-bearing, and disappear when the patient is resting, but later pain is present all the time, although it is increased by use of the foot.

This may be described as the typical history: firstly, pain which appears during falling of the arch, which may be called the stage of foot strain; then definite falling of the arch which may be partial or complete; but, although the disability can be recognized with comparative certainty from this train of signs and symptoms, many other points must be investigated before the appropriate treatment can be undertaken.

The normal foot has a range of dorsiflexion of at least 10 degrees above a right angle, and of plantar flexion at least 40 degrees below a right angle, with a varying amount of inversion and eversion. In the adult, especially in a woman, the power of dorsiflexion is usually diminished, and the limit of this movement of the foot, even with the knee bent, may be a right angle or even 5 or 10 degrees below this point. The exact range of movement must first be determined before commencing the treatment of any patient suffering from flat foot. If the foot cannot be dorsiflexed, excessive pressure is borne on the heads of the metatarsals with consequent flattening of the transverse arch. An examination of the foot in regard to its range of inversion and eversion is equally important. If inversion of the foot cannot be performed, either actively or passively, then it is obvious that no benefit will follow shoe alterations or the use of insoles, which are designed to alter the line of weight-bearing. The varying types of acquired flat foot may be most suitably described under the following simple clinical classification:

(*a*) Mobile.

(*b*) Rigid $\begin{cases} \text{Fibrous.} \\ \text{Bony.} \\ \text{Spasmodic.} \end{cases}$

In the first or *mobile* type of flat foot the deformity and, as a rule, the pain are present only during weight-bearing, but when relieved from strain the normal shape of the foot is restored and the pain usually disappears, or at least is considerably relieved.

In the second or *rigid* type this restoration of the normal shape of the foot, after the removal of body-weight, does not take place, and the deformity remains more or less constant.

1. Fibrous Rigid Flat Foot

In this subdivision are included those cases of flat foot which cannot be restored to normal shape, either passively or actively. The rigidity is usually caused by the presence of adhesions, which have formed as a result of long-continued ligamentous strain or following infection of the tarsal or tarsometatarsal joints. In the first group the adhesions are extra-articular, and in the latter fibrous bands are present also between the roughened articular surfaces (Fig. 112).

FIG. 112.—Rigid Flat Foot due to arthritic change between scaphoid and astragalus

2. Bony Flat Foot

Here, as a result of trauma, or of long-continued displacement, or septic infection of the tarsus, definite structural alterations have taken place in the bones of the foot; attempts at passive inversion of the foot are always unsuccessful, and, although the deformity is often severe, even prolonged weight-bearing may cause little pain or discomfort.

3. Spasmodic or Spastic Flat Foot

Although muscular spasm is present in many types of painful feet, the clinical entity, known as spastic flat foot, occurs as a rule in boys between the ages of 14 and 18 years. The foot is firmly fixed in extreme eversion with spasmodic contraction of the peroneal muscles; the absence of any true mechanical block to inversion may be demonstrated under anæsthesia, when the foot can easily be moved into any desired position. The typical deformity is seen in boys who have taken on heavy work, such as carrying parcels or heavy weights, directly after leaving school. Although many ingenious theories have been advocated to explain the origin of the

condition, none of them has received general acceptance. The most popular theory is that the muscle spasm is protective in character and caused by the occurrence of a traumatic arthritis or synovitis of the astragalo-scaphoid or sub-astragaloid joint. Support for this theory is lacking, as, even when the deformity is of long standing, no radiographic changes can be seen in the suspected joint. There are, however, certain clinical features which are more or less constant, firstly, a definite tenderness over the internal lateral ligament of the ankle, and secondly, tenderness and occasionally pain along the peroneal muscles.

The deformity is also occasionally associated with a developmental abnormality of the bones of the tarsus, in which the os calcis articulates or forms one continuous bony mass with the scaphoid. The abnormality cannot usually be recognized in antero-posterior or lateral radiographs, but when present it is clearly demonstrated if the picture is taken obliquely from above downwards and inwards. When present this abnormal bone formation prevents correction of the deformity, even under complete anæsthesia, and its presence may be suspected by the appearance of muscle spasm at a much earlier age.

There are thus two definite clinical groups in which this condition of spasmodic or spastic flat foot can be recognized. The first in children between 5 and 7 years of age in whom, almost invariably, a bony bridge or articulation exists between the scaphoid and the os calcis. The second, and more common type, occurring usually in boys of 14–15 years of age, in which no bony abnormality can be demonstrated, and for whose cause no suitable explanation has yet been advanced.

Treatment of Flat Foot

Treatment of the acquired type of flat foot consists mainly in correction of the line of weight-bearing in the foot from the abnormal to the normal, which is the line of the 2nd metatarsal, and the building up of the strength of the muscles and tendons which support the arch in its new position. If the foot is mobile, then deviation of body-weight is a simple procedure, but, if the foot is rigid the alteration may be obtained only by operation, or may indeed be impossible.

Treatment of Mobile Flat Foot. So long as the foot is mobile its line of weight-bearing can be easily corrected. The simplest method is by raising the inner margin of the heel and sole of the shoe as described by Thomas (Fig. 4), in which the inner side of the heel of the shoe is raised one-eighth or one-quarter of an inch and the body-weight transferred to the outer side of the foot and shoe. The muscles on the inner side of the leg are relaxed and relieved from the strain which they have previously borne, while, at the same time, the small muscles of the foot are supported by the alteration of position. The alteration is made as

follows: the original heel of the shoe having first been removed, a new heel is built extending forward on the inner margin half an inch farther than previously, while the whole of the inner border of the heel is raised higher than the outer border. The extent of the raising of the inner border of the heel depends largely upon the age of the patient. Thus, for a child, one-eighth or one-sixth of an inch is usually sufficient to give a complete correction of the deformity, while for the adult this may be slightly increased. Accompanying this tilting of the heel, a similar tilting of the forepart of the foot is usually given by the use of a small patch of leather, one layer in thickness, which is placed on the inner side of the sole under the head of the 1st metatarsal. The object of the alteration is not simply the correction of the alignment, but the cure of the condition of flat foot. In its altered position the small muscles of the sole and the stronger muscles of the calf are able to act to advantage and develop while they are relieved from overstretching. If, in the adult, it is desired only to provide relief of the pain and discomfort caused by the deformity, this can be obtained by the application of one of the many types of foot plate made from casts of the foot taken whilst it is held in the corrected position

Treatment of Spasmodic Flat Foot. The treatment of spastic flat foot naturally depends on the presence or absence of the bony abnormalities already described. If the abnormal bony bridge is present, correction of the deformity is only possible by its division, and the implantation between the os calcis and scaphoid of soft tissues which will prevent their reattachment. Through a dorsal incision the short extensor muscles of the foot are first detached at their origin from the os calcis, and, after separation of the two bones, the detached muscles, which still retain their nerve supply, are tucked into the gap.

The operation is followed by non-weight-bearing exercises for at least 8 weeks before the normal activities are resumed, the tendency to eversion being corrected by the alteration to the heel of the shoe (Fig 4)

When the bones of the foot are normal, the outstanding clinical feature is the contraction of the peroneal muscles, which is solely responsible for the deformity. Because of this, operations to divide the tendons of the peronei have been practised for many years with indifferent success. Later the simple division of the tendons was supplanted by the removal of an inch or more of their substance in an effort to prevent their restoration and recontraction. An equally good result is obtained by moulding the foot into over-correction under anæsthesia, the heel being first inverted while the front of the foot is adducted and somewhat pronated. The foot is then retained in this position in a plaster cast for at least 8–10 weeks. This prolonged fixation may lead to a temporary stiffness, which yields rapidly to physiotherapy.

After removal of the plaster case, weight-bearing is allowed only when

the heel of the shoe has been altered as already described. Occasionally it is necessary to maintain the correction more effectively by the use of an outside iron, which is retained for some months.

Treatment of Fibrous Flat Foot. In this group are included two distinct sub-sections which differ in their mode of origin, prognosis and treatment. The first group is that in which adhesions follow persistent stretching of the supporting ligaments, the strain and subsequent formation of adhesions occurring at the insertion of the ligaments into bone. Adhesions of this type, which do not involve any of the true joint structures, can be treated successfully by manipulation, followed by exercises and the wearing of suitably altered shoes to prevent recurrence of the conditions which were responsible for the formation of the adhesions. The result of this treatment is excellent. mobility is restored to the foot, pain and tenderness diminish or disappear, and with persistence in after-treatment recurrence need not be feared.

In the second group the adhesions are usually both intra- and extra-articular; the cause is, as a rule, a sub-acute infective condition, or a chronic arthritis by which the joint surfaces are altered and roughened. The differentiation of the two types is sometimes difficult, but, with the history and good radiographic examination, it is possible to distinguish between them.

In this second group manipulation is only of value in correcting the line of weight-bearing, as it is obvious that with the roughened joint surfaces restoration of the normal range of movement is impossible. Correction is obtained under anæsthesia, and when the foot has been placed in the optimum position a plaster cast is applied and maintained for at least 2 months to reduce the tenderness which always follows on the trauma of correction. Following the fixation, a suitable metal insole may be used to maintain the correction and prevent subsequent strain. The condition of the foot can also be improved by massage, contrast bathing with hot and cold water, and occasionally by ionization, the improvement in the circulation thus produced being followed by considerable relief in walking.

Treatment of Bony Flat Foot. As a rule, a patient suffering from bony flat foot has few complaints of pain or tenderness; the deformity is obvious, as it causes a complete absence of spring in walking the foot being raised and lowered as if it consisted of one solid mass.. Attempts to alter the shape of such a foot are useless, and treatment is necessary only when the falling of the arch is not yet complete. When pain is present relief may be gained by the use of altered shoes, or moulded insoles, which prevent further falling. In the more acutely painful feet, fixation in plaster, without attempting to correct the deformity, is often successful. Operative correction of the deformity is very rarely advisable, and then only as a last resort when long-continued efforts at conservative treatment

have failed to relieve the pain. If considered advisable, a wedge of bone may be removed from the tarsus, the base of the wedge being on the inner side of the foot and the apex at its outer border. As a result of the operation the appearance of the foot is improved, but there is, as a rule, little improvement in walking and no increase of mobility.

HALLUX VALGUS

This adduction deviation of the great toe is probably the commonest of all the deformities of the adult foot and is frequently present for many years without causing any discomfort. Although occurring occasionally as a congenital deformity, in the vast majority of instances it is the direct result of wearing badly designed shoes. As a result of adduction of the great toe, the four outer toes are pushed laterally and compressed between it and the side of the shoe (Figs 113 and 114). Because of the displacement, the base of the 1st phalanx of the great toe articulates on the side of the head of the 1st metatarsal, *with the result that the shaft of* this bone is gradually pushed away from the 2nd metatarsal, and a wide gap is opened up between the heads of these two bones. The head of the 1st metatarsal then forms a prominent projection on the inner side of the foot, here it is subjected to constantly repeated traumata which lead to a definite thickening of the bone itself and to the formation of osteophytic outgrowths round its articular margins. The increased pressure of the head of the metatarsal on the side of the shoe usually results in the formation of a bursa under the skin at this point This bursa, to which the description of bunion has been given, may remain small or may become greatly enlarged, inflamed or infected.

FIG. 113 —Bi-lateral Hallux Valgus, with dorsal displacement of the 2nd toe

SYMPTOMS

The symptoms produced by the deformity of hallux valgus can never be judged by its appearance. Thus, an extreme degree of deformity may be present for many years without causing any pain or discomfort, when present, pain is complained of over the tender and swollen joint, with or

without signs of inflammation in the superimposed bunion Indirectly, the deformity is responsible for pain in other parts of the forefoot; thus, the spreading out of the anterior portion of the foot is usually followed by tenderness under the heads of the 2nd, 3rd and 4th metatarsals, owing to the falling of the transverse arch, and the displacement and curling of the outer toes is usually responsible for the development of callosities and corns on the dorsum of their first interphalangeal joints. Frequently a dislocation of the 2nd, or of the 2nd and 3rd metatarsophalangeal joints can be recognized, the ligaments of these joints gradually yielding to the constantly deforming pressure of the great toe.

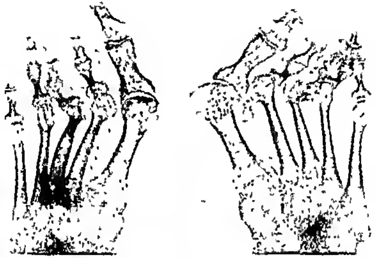


FIG. 114.—Marked Hallux Valgus, with clawing of the outer four toes as a result of Rheumatoid Arthritis

TREATMENT

The treatment to be adopted depends largely on the degree of deformity present and on the presence or absence of the associated corns and callosities. In its early stage the deformity may be successfully treated by the wearing of suitable shoes. In these the heel and ankle are firmly gripped, while the front of the shoe—which is straight along the inner border—allows complete freedom to the great toe. The application at night of a corrective splint along the inner border of the foot is of some advantage, but the wearing of any sort of wedge between the great toe and the second is often definitely harmful, as it causes increased pressure on, and increased deformity of, the other toes. Raising of the heel of the shoe on the inner border to the extent of one-sixth of an inch is helpful in

correcting the eversion of the foot which so frequently accompanies the hallux valgus deformity.

These simple measures can only be successful in the treatment of a comparatively slight deformity and cannot be sufficient in the more severe degrees which are accompanied by pain. When it is evident that more radical measures are required, the malalignment should be corrected by operation, of which many different types are practised. Of these, two are most commonly employed: in the first the base of the first phalanx of the great toe is removed, while in the second the whole or part of the prominent head of the first metatarsal is taken away.

Removal of the Base of the Phalanx. This operation is performed through a straight incision over the upper and inner aspect of the great toe-joint. The incision extends for 2 inches, one-third being over the head of the metatarsal and two-thirds over the phalanx. The joint is freely opened and the base of the phalanx freed from its ligamentous attachments; the phalanx is then divided with bone-cutters about half-way between the head and the base, and the basal portion is then removed from the wound, care being taken to avoid injury to the underlying flexor tendon. The raw surface on the remaining distal fragment of the phalanx is smoothed, and after freeing the soft tissues from the inner aspect of the head of the metatarsal, any osteophytic outgrowths should be removed The flap of soft tissue is now sutured into position over the raw area left on the side of the metatarsal head, and the skin closed This usually completes the operation, but, in the case of extreme deformity, even after removal of almost half the phalanx, it may still be impossible to bring the toe into line with the 1st metatarsal on account of the contraction and displacement of the tendon of the extensor proprius hallucis muscle. When this blockage to correction is evident, the tendon may be divided by a tenotomy knife at some distance above the site of operation. It must never be divided in the operation wound because of the danger of involvement of its cut ends in the resulting scar. If the tendons of the other toes are so contracted that they prevent full flexion at the metatarsophalangeal joints, they should be similarly divided, and the anterior arch of the foot moulded into the normal position, which can be retained by a plaster-of-Paris cast for 3–4 weeks. Following the operation, the great toe should be fixed in a position of hallux varus for at least a fortnight Gentle passive movements of the toe should be employed from the third or fourth day after operation, while at the same time the patient is encouraged to move the toe voluntarily. Walking can be resumed after three weeks, at first, on account of the swelling and dressing, in a wide loose slipper, and later in a well-fitting shoe of which the inner border is straight.

Recurrence of deformity is easily prevented by the use of a small wedge of wool, which is placed between the great and the second toes, and retained there until voluntary power is restored (Fig. 115).

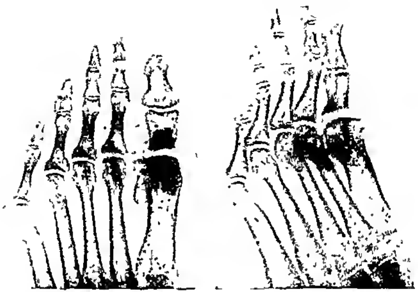


FIG. 115.—Result of removal of Base of first Phalanx.

Removal of the Head of the 1st Metatarsal (Mayo's Operation). This operation of removal of the head of the metatarsal is the commonest of all the surgical procedures used in the treatment of hallux valgus. When carried out correctly it is entirely successful in removing the great deformity, but it has the disadvantage of weakening the foot by removing the inner pillar of the transverse and the anterior pillar of the longitudinal arches, and is not to be recommended in the case of a patient whose work involves long-continued standing or walking, because of subsequent falling of the anterior arch and the disabling pain which so often accompanies this complication.

The head of the metatarsal is approached through a vertical incision 2 inches in length over the upper and inner border of the great toe-joint. After freeing the head of the metatarsal from its ligamentous connections the neck of the bone is divided close to the margin of its articular surface, sufficient bone being removed to allow the toe to be brought into alignment with the metatarsal. The anterior divided end of the metatarsal should then be shaped into a rounded knob which rests in line with, but not in contact with, the articular surface of the first phalanx. The operation is completed by suture of the layers of divided ligaments, subcutaneous tissue and skin, and the correction maintained until walking is permitted in 4–6 weeks. Because of the danger of falling of the transverse arch, it is advisable that a moulded support (Fig. 116) should be used to retain the position of the foot for at least 6 months.

Following any type of operation, recurrence of the deformity must be guarded against by the use of suitably designed shoes which allow complete freedom of the front of the foot. Patients should be warned of the danger of recurrence of deformity if they continue to wear high-heeled

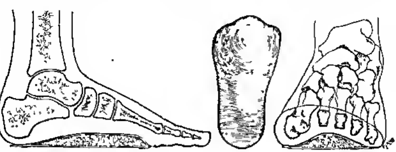


FIG 116—Metatarsal Insole showing support given to heads of Metatarsals.

pointed shoes, in which the great toe is again forced to the middle line of the foot. When the transverse metatarsal arch has become stretched, an insole (Fig. 116) *is of considerable help in relieving pressure and pain*, but its use should be accompanied by massage and exercises designed to develop the muscles of the foot and to improve its mobility.

Other Operative Procedures. Other less radical operative measures are often employed for the correction of the deformity and the relief of pain in *hallux valgus*. Their use should be confined to those patients in whom the deformity is not gross, and in whom the hallux valgus is not associated with deformities of the other toes. When the pain is caused by osteophytic outgrowths on the metatarsal head, relief follows the removal of these bony prominences, combined with a subcutaneous division of the capsule on the opposite side of the metatarsophalangeal joint. The correction of the alignment of the toe by the removal of a wedge of bone from the neck of the first metatarsal is a comparatively simple procedure, which gives a satisfactory result if the correction is maintained for a sufficiently long period.

HALLUX RIGIDUS

Hallux rigidus, as its name indicates, is characterized by a limitation of the normal range of movements in the great toe-joint. This limitation is at first confined to dorsiflexion, but, as the condition becomes more advanced, all the movements are affected, and the joint may become completely stiff and even plantar flexed. With the increasing rigidity of the metatarsophalangeal joint, the range of dorsiflexion in the inter-

phalangeal joint is greatly increased, so that eventually this joint may be subluxated.

Symptoms

The onset of the disability is seen at two separate age periods, the first group occurring in adolescence and the second in later adult life. The adolescent type occurs in children of either sex, more especially in those with long narrow feet which are somewhat everted on weight-bearing. Because of this peculiarity in the shape of the feet it is difficult to obtain the right type of shoe, and the child is often fitted with a shoe which is too short and so causes constant pressure on the end of the great toe. The joint becomes slightly swollen and tender, and attempts to dorsiflex the toe beyond the horizontal plane cause a considerable amount of pain, and are strongly resisted by the protective muscle spasm of the flexor longus hallucis and of the short flexors of the great toe. No bony changes can be seen in the radiographs taken at this stage, and complete immobilization of the joint in a plaster cast results in an increased range of movement. This reaction of the toe to fixation illustrates that the limitation of movement is caused solely by inflammation in the joint structures, as rest has led to a reduction of inflammation and to an increased range of movement.

When occurring in the adult the rigidity of hallux rigidus is invariably caused by osteoarthritic changes in the head of the 1st metatarsal and in the base of the 1st phalanx. The joint is greatly thickened by the bony outgrowths which can be felt under the skin; the muscle spasm is much less, and prolonged fixation does not lead to an increased range of movement. In contrast to hallux valgus, which occurs almost invariably in women, hallux rigidus is a condition of adult males.

The exciting cause in each case would appear to be constantly repeated injuries; in the adolescent this is probably brought about by the wearing of stock shoes which are much too short for the long narrow foot. In the adult repeated knocks on the joint itself and on the end of the toe have produced a true traumatic arthritis of the metatarsophalangeal joint (Fig. 117).

Treatment

This depends largely on the age of the patient and on the condition of the joint structures. In the young patient, shoes of suitable length should be obtained and the painful movement of dorsiflexion of the toe prevented by the application of a transverse bar of leather on the sole of the shoe behind the tender joint, or by the insertion of a layer of metal in the sole, thus preventing movement of the joint. At the same time eversion of the foot should be dealt with by raising the heel of the shoe on the inner side. If these measures do not lead to a diminution of discomfort, or if arthritic changes are already present, then operation of a

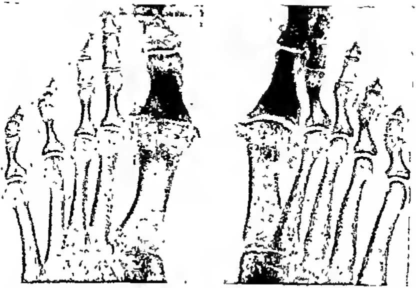


FIG 117.—Bilateral Hallux Rigidus, marked osteophytic outgrowths.

similar type to that used in hallux valgus is necessary In the adult complaining of pain and disability, operation alone can give relief of pain and restoration of movement.

HAMMER TOE

A deformity which usually occurs in the second, but may be present in the third or fourth toes. It commonly results from wearing unsuitable, narrow pointed shoes, in which the toes are crowded together; the great toe is forced towards the middle line of the foot, and, in order to accommodate itself to the space provided, the affected toe is forced into the typical deformity of hyperextension at the metatarsophalangeal joint, hyperflexion at the 1st interphalangeal joint, and usually hyperextension at the terminal joint. The deformity of itself causes little or no discomfort, and the patient's attention is generally drawn to the condition by the formation of a bursa or a corn on the dorsum of the 1st interphalangeal joint. Occasionally the corn or bursa becomes inflamed or septic, and the infection may even extend into the underlying joint, leading to suppurative arthritis or osteomyelitis of one of the phalanges.

Treatment

Prevention of the deformity is comparatively simple; shoes should be sufficiently long and wide in front to allow complete freedom to the toes.

A mild degree of the deformity can be corrected by the use of a small straight splint, which can be applied to the toe at night, and by day the deformed toe may be controlled by a piece of tape passing over it, and under the adjacent toe on each side. These simple measures are only applicable when the deformity is slight and is uncomplicated by septic changes in the skin. When the toe is seriously deformed and is causing pain and disability operative correction is essential.

Operation. Even in the presence of an extensive septic infection of the deformed area, amputation of the second toe should never be performed on account of the danger of increasing the deformity of the great toe, which would thereby lose support and fall into the space left vacant as a result of the amputation. The object of operative treatment is the provision of a strong straight toe, in which the deformity cannot recur, and which by its presence maintains the alignment of the great toe. Correction of the deformity should be combined with arthrodesis of the 1st interphalangeal joint, and the operation should be undertaken only after the disappearance of all traces of septic infection.

An elliptical incision is made over the dorsum of the prominent joint, and the skin containing the corn is removed, with the underlying portion of the extensor tendon and capsule. The cartilage, with a piece of the underlying bone, is then removed from the adjacent articular surfaces of the two exposed phalanges, and their two raw bony surfaces are fixed firmly together by straightening the toe. A deep mattress suture of silkworm gut through the skin, tendon and periosteum on both sides of the incision holds the bones firmly in position and should not be removed for a fortnight. Before completing the operation the extensor tendon, which holds the proximal phalanx in dorsiflexion, must always be divided by a tenotome behind the head of the metatarsal, and the alignment maintained by the use of a small straight splint applied to the toe and retained until bony consolidation is complete.

METATARSALGIA OR MORTON'S DISEASE

Spreading of the forefoot with falling of the transverse arch and clawing of the toes is a very common deformity, and is usually associated with pain under the heads of one or more of the medial metatarsal bones, but a different clinical condition in which, without extreme flattening of the arch, the patient complains of intermittent spasmodic pain under the heads of one or more of the three medial metatarsals, has been described by Morton. He attributed the pain to traumatic neuralgia of the digital branches of the plantar nerves, and considered that the injury was caused by crushing of these branches between the heads of the metatarsal bones.

Betts (1940) has shown that in the majority of patients suffering in

this way a neuroma can be found in one of the digital nerve branches, passing along the plantar aspect of the metatarsal head.

Symptoms

In the intervals between attacks of acute pain the foot is usually comfortable; at most there is a feeling of aching in the affected region, where there may also be slight tenderness on pressure. On the onset of the acute attack, which usually occurs during walking, the muscles of the foot develop a condition of acute cramp and the pain remains severe until this cramp can be relieved; the patient finds that the best method of obtaining relief is by removing the boot, massaging the foot or pulling out the affected toe, after which walking can be resumed.

Signs

There is, as a rule, some widening of the front of the foot with falling of the transverse arch. No swelling is present over the affected area, but dorsiflexion of the foot is usually limited owing to contraction of the calf muscles. Although radiographs reveal no bony abnormality, they may indicate the falling of the anterior arch and the separation of the metatarsal heads. Usually a definite point of acute tenderness can be found on digital pressure under the head of the affected metatarsal

Treatment

Conservative treatment, which should be tried in every case, consists in the relief of the tender area from all weight-bearing This relief can be obtained by an insole extending from the heel to the area of the sole just behind the heads of the metatarsals (Fig. 116). Similarly, the application of a bar of leather across the sole of the shoe behind the ball of the foot may give relief, but, as a rule, conservative measures are not successful and operation must be undertaken.

Operation. When the site of greatest tenderness has been definitely localized a vertical incision, 1½ inches in length, is made through the skin of the ball of the foot. After freeing the thick subcutaneous tissue, the digital nerve in this area is sought and examined. As a rule, a definite neurofibroma can be seen in its substance, and when this has been found the nerve should be divided proximal to the enlargement. If it has been impossible to define the exact site of tenderness a transverse incision should be made through the skin at the base of the affected toes, thus allowing a wider inspection of the area and an opportunity of finding the affected nerve branch. These incisions through the thick skin of the ball of the foot heal without difficulty, and leave a scar free from tenderness.

Following the operation no special precautions are necessary, the localized anæsthesia of one toe causing no disability or discomfort.

Removal of the Head of the Metatarsal. This operation, which was previously practised for the cure of metatarsalgia, was usually not successful in relieving the pain, as it was based on the belief that the cause of the disability was the intermittent pressure of the metatarsal head on a normal digital nerve.

CLAW FOOT

This very common deformity of the foot, which is characterized by increased elevation of the arch, combined with acute dorsiflexion of the toes at the metatarsophalangeal range, and acute flexion at each of the interphalangeal joints, was first described by Duchenne, who attributed it to disease of the central nervous system. In type the deformity is almost identical with that present in the condition known as "Claw Hand," from which the name is derived.

If, for any reason, the action of the interossei and lumbrical muscles is lost, the other muscles acting on the toes appear to overact and cause deformity of the front of the foot. It naturally follows that, with weakness or paralysis of these intrinsic muscles, the flexor and extensor muscles become contracted and the deformity of claw foot appears more or less rapidly. The commonest cause of this loss of action of the intrinsic muscles is undoubtedly infantile paralysis, but the deformity of claw foot can only occur after an attack of this disease if there has been a recovery of the action of the flexor and extensor muscles with a residual paralysis of the small muscles of the foot. Thus, claw foot usually follows an attack of infantile paralysis from which recovery is apparently complete, or else a very mild attack which has caused so little general disturbance that its occurrence has remained unsuspected and has resulted in paralysis only of these small and easily injured muscle bundles.

The deformity, however, does not follow only on infantile paralysis, but often results from prolonged exposure of the foot to cold, frost and damp—a condition which was seen in its most typical form as the trench foot of the 1914–18 war, or of the exposure or immersion foot of the recent war. In either of these conditions the circulation in the foot is severely diminished, the foot becomes blue and cold and the intrinsic ligaments and small muscles of the foot become fibrotic.

Another type of claw foot is seen commonly in young children; it is characterized by a gradually increasing deformity, for which no cause can be discovered. It has been suggested that the deformity in this group is caused by a spina bifida occulta of the lower lumbar vertebræ,

but examination of a series of cases does not support this theory, and it seems as if a possible cause may be found in the continued wearing of short tight shoes. In these the toes are pushed backwards into the position of deformity, the sole is not allowed to flatten normally when bearing the body-weight, and the foot is so tightly compressed that the normal circulation through the intrinsic muscles is prevented.

Appearance. With a mild degree of deformity there is slight increase in the height of the arch, combined with a tendency to clawing at the toes (Fig. 118), but, as a result of weight-bearing, the deformity is corrected and the foot appears almost normal.

With severe deformity the arch is very high, the toes are rigidly

Fig 118—Slight Claw Foot

contracted in a position of hyperextension, which may be so extreme that subluxation occurs at the metatarsophalangeal joints with flexion at each of the interphalangeal joints. In some instances the tendo achillis is also contracted, the foot remaining in a position of equinus, with occasionally a slight degree of inversion, and, as a result of the excessive pressure on the ball of the foot, painful callosities appear under the heads of all the metatarsals.

The radiographic appearance in the mild deformity demonstrates the tarsal bones normal in shape and structure. In the severe type of the deformity wedging of the bones becomes apparent, especially the scaphoid and internal cuneiform bones, which may be compared in structure and position to the keystones of a high arch.

Symptoms

Even a severe degree of deformity may cause no discomfort or pain, but, as a rule, sooner or later pain and tenderness are complained of under the ball of the foot, where callosities are usually present, and along the dorsum of the 1st interphalangeal joints, where corns have formed as a result of excessive pressure by the shoe. Occasionally the skin round the callosities becomes infected, and the whole area may eventually become the site of discharging sores.

Treatment

In the early stage treatment consists simply in the provision of shoes which are sufficiently wide and long to allow for expansion of the foot in weight-bearing. At the same time the plantar fascia and tendo achillis should be stretched by lowering the height of the heel of the shoe. At night correction is continued by the application of right-angled foot splints, which maintain the correction of the deformity.

When the deformity is more pronounced correction is possible only by operative treatment, which consists either in division of the contracted soft tissues, or, when it is obvious that deformity is present in the tarsal bones, by an operation on the tarsal bones by which the disparity in length of the dorsal and plantar surfaces of the foot can be diminished.

Tenotomy of the Plantar Fascia. The contracted plantar fascia is divided by a small tenotomy knife, the skin puncture being made at a point in line with the internal malleolus and about three-quarters of an inch above the sole. The tenotomy knife is inserted here and placed in position under the skin, and the fascia divided by a series of saw-like movements of the tenotome. The division of the fascia must extend over a wide area, no single cut passing across its whole width. When the fascia is divided in this fan-shaped manner there is no tendency to splitting of the overlying skin, which might otherwise follow the correction of the deformity.

Stripping of the Under Surface of the Os Calcis (Steindler's Operation). With a more severe deformity simple tenotomy of the fascia is not usually sufficient, and a more complete correction can be obtained by stripping the structures attached to the lower and inner surface of the os calcis, as described by Steindler.

A horizontal incision, 2½ inches in length, is made along the inner border of the foot, parallel to and about three-quarters of an inch above the sole, extending posteriorly to the level of the internal tuberosity of the os calcis. Through this incision the plantar fascia is defined and divided close to its calcanean attachment. The short muscles attached to the inner side of the os calcis are stripped off by blunt dissection,

and the calcaneo-scaphoid and calcaneo-cuboid ligaments, which can now be seen in the depths of the wound, are freely divided, or detached by the use of a sharp pointed elevator.

With either of these procedures division of the soft tissues must be followed by a thorough and systematic stretching of the sole by means of the Thomas wrench (Fig. 119), in order that the contracted tissues, which cannot be dealt with by the tenotome or knife, are sufficiently stretched. When flattening of the arch has been completed by these methods the toes are, as a rule, still firmly fixed in a position of flexion, and a recurrence of the deformity is probable unless the flexor and extensor tendons to each toe are also divided. This division of the flexor and extensor tendons of the four outer toes causes no permanent loss of function, as the tendons become reformed in a few months. In the case of the great toe it is advisable to transplant the tendon of the extensor proprius hallucis muscle into the neck of the 1st metatarsal, the continuing

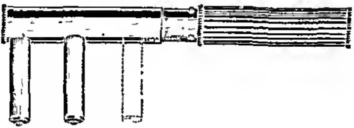


FIG 119—Thomas Wrench

action of the muscle tending to lift the head of the metatarsal and diminish the elevation of the arch

Even if carried out thoroughly, these operations on the soft tissues can only be effective in those cases where the structure of the tarsus is normal, or approximately so. If the deformity is so far advanced that the tarsal bones are already wedge-shaped, as shown in the radiographs, recurrence of the deformity will inevitably take place, as the flattening of the sole has resulted simply from the opening out of the lower portions of the intertarsal joints. Under these circumstances the correction of the deformity, which has been obtained by the division of the soft tissues, must be accompanied by the removal of bone from the dorsum of the foot, in order that the normal relationship of the dorsum and plantar aspect of the tarsus may be restored. After any of these operations the foot is fixed in a plaster case in the corrected position for a period of at least 8 weeks. Where excision of bone is necessary this period should be extended to 3 or 4 months.

After-treatment consists in wearing of suitable wide, low-heeled shoes

and the application at night of right-angled splints, so that recurrence of the deformity may be prevented until muscle balance has been restored by suitable exercises and massage, combined with daily stretching of the toes.

In the rarest and most severe type of deformity, where the foot is rigid and blue, and so painful that the patient may even ask for amputation, the operations described above will be found to be ineffective. Relief in these cases may be given, and a useful foot obtained, by an operation which consists in amputation of all the toes at the metatarso-phalangeal joints through a large plantar flap, followed by astragalectomy. These two apparently very radical procedures may render unnecessary the performance of amputation, which would otherwise be the only procedure possible. This very severe operation, although useful in selected cases, is necessary only on rare occasions.

KÖHLER'S DISEASE OF THE FOOT

Köhler, in his text-book on Roentgenology, has described two pathological conditions of the bones of the foot; the first—the condition which is commonly associated with his name—is an affection of the tarsal scaphoid occurring only in children and characterized by an alteration in the shape, size and density of the bones, as seen in the radiograph.

The usual signs and symptoms of the condition are aching on the inner aspect of the tarsus and an intermittent limp, and although there is usually no obvious swelling, there may or may not be slight local tenderness on pressure. The radiograph of the foot (Figs. 120*a* and 120*b*) shows that the scaphoid is compressed in an antero-posterior direction with a consequent lateral expansion. Many suggestions have been made in regard to the etiology, and although agreement has not been reached on this point, the most probable cause appears to be trauma, because the usual result of rest and relief of body-weight for a period of 2–3 months is a complete restoration of the normal structure and radiographic appearance of the affected bone.

The second condition associated with the name of Köhler, and sometimes also with that of Freiburg, is an enlargement of the head of the 2nd or 3rd metatarsal, appearing only in children and young adults, previous to the fusion of the epiphysis with the shaft of the metatarsal.

As a rule, the patient complains of persistent aching in the fore part of the foot, especially over the affected bone, which is distinctly tender on pressure. Occasionally, however, aching is absent and the patient notices a steady enlargement of the head of the affected bone, which may

become so increased in size that the pressure of the shoe may cause an ulcer on the skin.

In either case examination reveals enlargement of the head and neck of the affected metatarsal, which is usually tender on pressure,

(a)

(b)

Fig 120a.—Early Kohler's disease of Tarsal Scaphoid
Fig 120b.—Later radiograph after 2 months' immobilization.

with a definite diminution in the range of movement at the metatarso-phalangeal joint. The radiograph shows the head of the metatarsal broadened, fragmented and diminished in its depth (Fig. 121). It has an appearance very similar to that of the upper articular surface of the femur in Legg-Perthe's disease of the hip, with the same fragmentation of the articular surface and the same widening of the head and neck of

the bone. The enlargement usually ceases about half-way along the bone but may occasionally spread almost to the base.

As in all these instances of epiphyseal fragmentation, the cause is a matter for conjecture, but some help is given by a consideration of the anatomical arrangements. In the first place the head of the 2nd metatarsal is normally situated further forward than any of the others, although occasionally the head of the 3rd is level with, or even slightly in advance of, the 2nd. This would seem to indicate that jars on the front of the foot are mostly taken by the head of the 2nd or 3rd meta-

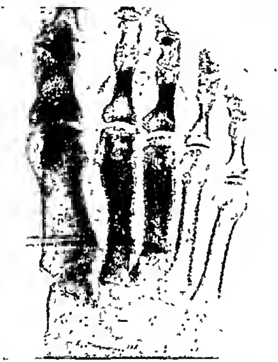


FIG. 121.—Köhler's disease of head of 2nd and 3rd metatarsals

tarsal. Secondly, in no instance yet recorded has abscess formation or osteomyelitis developed, a complication which would almost certainly have appeared had the condition been of bacterial origin, as has been frequently suggested.

TREATMENT

The injured and inflamed bone must be relieved from the repeated traumata which it receives in walking. For the first few weeks complete rest is essential, it is not usually necessary to immobilize the foot in a plaster cast or splint, relief from weight-bearing being sufficient to

produce a rapid improvement. Later, by the use of an insole or metatarsal bar on the shoe, protection can be continued until the tenderness has disappeared and the structure of the bone has been restored.

Occasionally the head of the bone is so enlarged that more radical measures are necessary. By operation, the head of the affected metatarsal may be either reshaped to its normal contour or removed. Although the latter method is more certain of relieving the immediate pain and tenderness, it has the disadvantage of diminishing the strength of the foot to some extent, and, as a rule, the remoulding of the head to approximately the normal shape is sufficient to relieve the patient without weakening the transverse arch.

MARCH FOOT OR MARCH FRACTURE

A crack fracture may appear in the neck of the 2nd or 3rd metatarsal bones without any history of severe injury. The frequency with which the fracture was seen in army recruits led to its description as march foot. It was previously considered that this fracture resulted from the application of some slight extra strain or twist to the foot at the end of a long march, when the supporting muscles of the leg had become tired and weakened, thus throwing the unsupported strain of body-weight on the metatarsal heads. As a result, the longest metatarsal, which is usually the 2nd, gave way at its narrowest and weakest portion. Further observations have not confirmed this simple explanation. In many instances the pain and aching are complained of before the radiographic appearances confirm the presence of a fracture, the patients complain of indefinite tiredness and aching in the foot, and clinical examination reveals thickening behind the head of the affected metatarsal.

The radiographs taken at this stage may show a decalcified but unbroken shaft of the metatarsal, with a fusiform deposit of new bone round its cervical constriction. Without any increase in the severity of the symptoms, further photographs taken a few weeks later show a line of fracture through the neck of the metatarsal in the region of the new bone deposit (Fig. 122).

ETIOLOGY

A very reasonable explanation of the cause of the bony lesion has been given by Mark Jansen. He suggested that the condition was the result of spasm of the interossei muscles which led to vascular obstruction and œdema of the periosteum and soft tissues. The œdema had two effects; first, the production of a decalcification of the affected bone, and secondly, the deposit of new subperiosteal bone in the same area.

As a result of some increased pressure on the front of the foot, the decalcified metatarsal yielded in its weakened portion and the fracture became apparent. The suggestion of an infection as the primary cause of the disability is not supported by clinical observation.

Clinical Signs

Aching over the site of the bony enlargement is frequently present before the fracture has occurred. In fact, the occurrence of the fracture

Fig. 122.—March Fracture of shaft of 2nd metatarsal.

does not increase the discomfort to any great extent. Swelling of the bone and tenderness on pressure can be appreciated, and this tenderness remains evident until consolidation has been obtained in the new callus.

Treatment

Rest from weight-bearing without any form of splint or fixation is usually sufficient to allow consolidation to occur rapidly, but if there is any possibility that the patient may bear weight on the foot, protection by means of a plaster case is advisable for 4–6 weeks.

After consolidation the bone feels thicker, but no permanent disability results. Protection from weight-bearing by the use of a suitable insole for 3–6 months is advisable when walking is resumed.

INGROWING TOE-NAIL

Overgrowth of the skin of the great toe at the lateral margin of the nail is often caused by careless cutting, by which a sharp spike of nail is left under the edge of the skin. Septic infection round the margin of the nail rapidly follows and considerable pain and disability are the usual result.

TREATMENT

Relief can often be obtained by wearing wide-toed shoes, which allow sufficient room for the forefoot without producing pressure on the inflamed toe. Careful cutting of the nail also helps considerably and may be sufficient to cure the disability.

If these measures do not reduce the inflammation, relief can usually be obtained by the removal of a small V-shaped wedge of nail and nail

FIG. 123.—Operation for radical cure of Ingrowing Toe-nail

fold, with subsequent suture of the edges, the operation only being undertaken when the infection has been removed by rest and dressings.

Unfortunately the operation is frequently followed by recurrence of the infection and a reappearance of the overgrowth of skin. Under these circumstances a more radical procedure is necessary. A curved U-shaped incision is made, extending round the apex of the toe, the base of the incision being joined by a straight cut across the dorsum of the toe just behind the nail bed (Fig. 123). The large plantar flap of skin is now dissected proximally from the phalanx, and when half the phalanx has been cleared the bone is cut through at this level. The distal half of the phalanx, together with the attached nail and nail matrix, is now removed, leaving a large plantar flap, which is turned upwards and sutured to the skin on the dorsum of the remaining portion of the phalanx. The result of this operation is usually excellent, and the resulting shortened toe does not inconvenience the patient in any form of sport or exercise.

TENDER HEELS AND SPUR FORMATION

Transient tenderness under the heels follows almost inevitably on prolonged rest in bed, and is complained of by every patient when activity is resumed after a long illness. This type of tenderness is caused by softening of the skin over the heel and by the loss of some of the subjacent fatty fibrous pad, but the bone itself shows no sign of abnormality, except for a slight generalized decalcification, which rapidly disappears when normal function is resumed, leaving no trace of the former tenderness.

There is, however, another type of persistent tenderness which occurs

Fig. 124.—Spur on Os Calcis.

at the same site on the under aspect of the heel, at the level of the tuberosity of the os calcis. The tenderness may or may not be accompanied by a spur-like outgrowth of bone, extending forward into the muscles of the sole, and varying in size from a slight roughness of the surface of the bone to a long hook-like projection (Fig. 124). Frequently these spurs are bilateral, although when present on both sides they are seldom of equal size, and the amount of tenderness complained of is in no way proportional to the size of the spur. A small spur may be present in one foot and give rise to a great amount of pain and discomfort, whilst on the other foot, which is entirely free from symptoms, a very large spur may be found in the course of a routine examination.

Etiology

The complaint of discomfort under the heel is usually associated with eversion and flattening of the foot, which causes an increased strain on

all the muscular and ligamentous attachments. As a result of this, an inflammatory reaction is set up at the point of maximum strain, forming a suitable predisposing cause to spur formation. The direct or exciting cause is always some type of generalized infection, which may be rheumatic, gonorrhœal or septic in character. That strain itself cannot be the sole cause of these bony outgrowths is evidenced by the complete absence of such spur formation in the weak flat feet of children, where continued strain on the muscles and ligamentous insertion is always present. As a rule, it will be found that sudden acute tenderness under each heel occurring in a young patient is due to septic or gonorrhœal infection, while in the elderly, bilateral tenderness, with or without spur formation, is the indirect result of rheumatism.

Treatment

Where a definite infective origin can be proved, treatment must first be directed towards its elimination. When this source has been dealt with, or where no definite infection can be demonstrated, relief can usually be given by the provision of a soft pad, which is placed in a hollowed out cavity in the heel of the shoe, in the centre of which the tender area rests during activity. This pad may of itself be sufficient to procure relief, but in most cases the eversion and flattening of the foot must also be attended to by suitable alteration to the heel of the shoe, raising it on the inner border in order that the stretched ligamentous structures on the inner aspect and sole of the foot may be relieved from strain Only when conservative measures are unsuccessful after prolonged and careful trial should removal of the spur be considered

Operation. The under surface of the os calcis is approached through a 3-inch horizontal incision over the inner aspect of the heel at the level of the lower border of the os calcis; after freeing from all its ligamentous attachments the spur is removed in its entirety, the rough area of bone left on the under surface being smoothed off before closing the wound. It is essential in removing the spur to remember that, although showing as a single spike in the radiograph, the abnormal bone really forms a wide ridge which must be removed completely if the operation is to be successful.

Weight-bearing is not permitted for 4 weeks following the operation, during which period contrast bathing and gentle massage will restore the normal circulation in the foot. Efficient after-treatment by relief of the tender area from pressure, and correction of any deviation of body-weight, should be carried out for at least 4–6 months, when a return to normal shoes is usually possible.

CHAPTER XVII

ACUTE ANTERIOR POLIOMYELITIS

This acute infective disease occurs in either epidemic or endemic form, the latter type occurring more frequently in Britain, although small epidemics, involving as many as 20 or 30 children, occur in localized areas.

The disease, which is characterized by a widespread infection of the central nervous system, is caused by the action of a virus, the relationship of which to the disease has been clearly demonstrated by a series of inoculation tests in monkeys. The organism, which is filtrable as it passes through asbestos and a Berkfeldt filter, resists light, heat, drying and freezing for a considerable period. It apparently enters the system by the nasal mucosa and is particularly resistant to the action of chemicals, a characteristic which renders extremely difficult the prevention of the spread of infection during the course of an epidemic. The chief primary pathological changes produced by the disease occur in the central nervous system, where the effects are of two main types:

1. Hæmorrhage and œdema of the cord.
2. Destruction of the anterior cornual nerve cells with subsequent degeneration of their nerve fibres.
3. Occasionally destructive changes with gliosis in the basal ganglia.

The destruction of the affected nerve cells may be solely the result of the abnormal pressure which is caused by the œdema, or it may be partly due to the action of toxin produced by the micro-organisms.

The first effect of the entry of the organisms is a widespread inflammation and small round-celled infiltration of the meninges; later this perivascular inflammatory change passes along the vessels into the cord itself, causing its greatest effect in the highly vascular anterior cornual cell area, where patches of œdema and infiltration are developed round the vessels. This cellular infiltration and œdema may be sufficient to obliterate the lumen of the vessels, with a consequent deprivation of blood supply to the anterior cornual cells. The grey matter of the anterior horns subsequently shows extensive degeneration, whilst the posterior horns, which are less highly vascularized, usually escape.

A similar inflammatory change may also affect the medulla and pons, producing areas of cellular degeneration at scattered points. With the degeneration of the anterior cornual cells the efferent nerve fibres atrophy, and the muscles supplied by them show signs of degeneration. The other tissues of the affected area also show signs of loss of nervous control, thus the bones of the affected area take part in this alteration. Although

these osseous changes do not appear for some months, the affected bones become thinner than normal, rarefaction is widespread, while the medulla is diminished in size, and considerable shortening in the length of the bone may follow on a severe involvement of a limb.

Symptoms

Incubation Period. From investigations which have been made, *chiefly in America, it appears that in the classical* onset of the disease there is an incubation period which varies from 2 to 32 days, during the early part of which the patient usually complains of headache or may appear to be "out of sorts." After one or two days there is apparently complete recovery until 6–14 days later when the signs of the disease become obvious with the typical paralysis.

Onset. With the onset of paralysis the child becomes very restless, there is a definite rigidity of the cervical muscles preventing anterior flexion of the spine, the cornea is glazed and the temperature varies from 100 to 105 degrees. Signs of gastro-intestinal irritation, such as nausea, diarrhœa and vomiting, are usually present, with profuse sweating and enlargement of the lymphoid tissues all over the body. The most constant sign, however, is the invariable tenderness of the paralysed muscles The child usually cries bitterly on being moved, or even touched, and lies quietly without discomfort so long as active or passive movements are avoided. Definite pain occurs less frequently but may be present as headache caused by congestion of the cerebral vessels. The child is generally drowsy, although convulsions may be seen, especially in poorly nourished children. In the acute stages of the disease the reflexes may be temporarily exaggerated, but, as a rule, this sign is of very short duration.

Although this classical syndrome may be seen occasionally in this country, the usual onset of the disease is entirely different The common story, as related by the mother, is that the child had been playing about perfectly well the day previously, but on waking up the following morning it was found that voluntary movements over the whole or part of the body were impossible, and on being lifted the child cried on account of the generalized tenderness of the affected muscles. Another common history is that the child, whilst apparently slightly below par from teething, or some childish illness, suddenly developed paralysis without showing any increase in the illness already present.

Diagnosis

The differential diagnosis must be made from such general diseases as tuberculous meningitis, cerebral thrombosis, acute transverse myelitis, pseudo-paralysis of rickets and osteomyelitis. Reliance must be placed

on the sudden onset, the presence of a flaccid paralysis, tenderness of the muscles and on an examination of the cerebro-spinal fluid.

In infantile paralysis, especially in the first week, the cerebro-spinal fluid is increased in amount to such a degree that on lumbar puncture it flows under increased pressure. The fluid is clear, the cell count is greatly increased from the normal 5–10 cells to hundreds, or even thousands, per cubic millimetre. At first the cellular content consists chiefly of polymorphonuclear cells. later mononuclear cells predominate, although the polymorphonuclears are also present in considerable numbers. In addition, the amount of globulin in the cerebro-spinal fluid gradually increases during the first month.

Extent of the Paralysis. As a rule, paralysis is widespread at the onset of the disease, almost the whole body may be involved, but soon the tendency to improvement appears and voluntary movement is restored to some of the affected muscles. This recovery may be complete in mild cases, but generally a residual and permanent paralysis, or paresis, is established, and atrophy of the paralysed muscles shows itself within 2 weeks. The outstanding feature of the paralysis is its almost invariable want of symmetry; any group of muscles may be attacked, and any muscle may be picked out of a group, leaving the others apparently normal.

Prognosis

Although in the severe epidemics which have occurred in America the death-rate reached the figure of 20–25 per cent, a fatal result of an attack of infantile paralysis has until recently been an uncommon occurrence in this country. Until the epidemic of 1947 the death-rate from infantile paralysis varied between 1 and 2 per cent, but this figure was considerably increased during that year. A fatal result may occur soon after the onset of the disease from involvement of the respiratory muscles, or later from complications of which the most frequent is pneumonia. As a rule, the result of the infection is a permanent residual paralysis of considerably less extent than the primary involvement.

Treatment

Although the disease does not seem to follow closely the ordinary rules of infectious diseases, and children who have been in direct contact with the infection frequently escape, yet the possibility of such infection has been demonstrated and the patient should always be isolated in the acute stages.

General Treatment

Serum Treatment. In those countries where the classical onset of the disease enables the diagnosis to be made before the appearance of the paralysis, considerable reliance is placed on the therapeutic value of the serum from a patient convalescing from the disease, given by

the combined intravenous and intraspinal method. Similarly, the use of immune horse serum is said to be followed by a lowering of the death-rate and by a diminution in the extent of the residual paralysis. One important point must be remembered in regard to the use of the sera—they apparently have no effect when the paralysis has already appeared and can only be of advantage in the pre-paralytic stage, which is so rarely diagnosed in this country. Hypertonic saline solution, when given intravenously, leads to a diminution in the size of the brain and spinal cord and a lessening of the cerebro-spinal fluid pressure, and is recommended by some. In this country, however, where serious epidemics are unknown, and where the onset is so often atypical, the value of such treatment is extremely problematical.

Lumbar Puncture may be performed with advantage in the acute stages of the disease if the signs indicate a considerable increase in the pressure of the cerebro-spinal fluid.

Local Treatment

The practical methods which undoubtedly help in the treatment in the acute stage are:

1. Complete rest of the paralysed muscles in the acute stage of the disease.

2 Prevention of deformities.

In the classical treatment of the disease the muscles are retained at rest in a position of relaxation until all tenderness has disappeared, and unless muscle recovery is complete recumbency should extend over a period of at least 6 months. The duration of the muscle tenderness may be diminished by the application of heat to the affected areas; the heat may be given by radiation, or by bathing with hot water, the increased circulation leading to a more rapid absorption of the inflammatory processes. When the paralysis is very extensive, and especially when the muscles of the trunk are involved, the period of recumbency must be extended to at least 12 or 18 months. Physical treatment by massage and graduated electrical stimulation is of the greatest help in the treatment of paralysis, but should not be started before the complete disappearance of pain and tenderness from the paralysed muscles If massage is given in the acute painful stage, it usually increases and maintains the tenderness. During the whole period of treatment it is essential that the affected areas should be protected from cold, the limbs should be warmly covered, while at the same time the tendency to deformities is prevented by the application of suitable splints.

Every muscle which shows any sign of involvement in the paralysis should be placed in a position of relaxation. If a paralysed muscle becomes overstretched, recovery of its function is delayed or prevented, even in the presence of complete recovery of the nerve cells and fibres acting on that muscle. There is no more important factor in the treat-

ment of infantile paralysis than this preservation of the paralysed muscles in their best possible functional position. This position of advantage in which the paralysed muscles are shortened and relieved from strain can be lost, either by the deforming action of gravity or by the over-action of the active opposing group of muscles, and unless both these factors are guarded against there is little possibility of recovery in the paralysed group.

The principle involved in the mechanical treatment of the paralysed muscles is extremely simple. By means of a suitable splint, which controls the position of the joint acted on by the affected muscle, the origin and insertion of the muscle are approximated and overstretching is thereby prevented. In the case of a more generalized paralysis, in which the opposing muscle groups are affected, the joint should be retained in the neutral position in order that the maximum relaxation possible is given to each group. Thus, in the case of the very common paralysis of the muscles of the shoulder girdle, the deltoid is stretched whilst the arm lies adducted to the side, relaxation of its fibres follows on abduction of the arm to the horizontal plane, where it may be maintained most easily by the wire abduction frame (Fig. 11). Similarly, in paralysis of the extensor muscles of the leg, fixation of the foot at right angles prevents stretching of the paralysed muscles, and this position is most easily maintained by the application of a right-angled foot splint (Fig. 125).

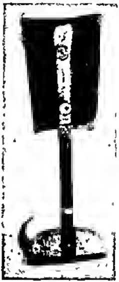


FIG. 125.—Right angled Foot Splint.

The same principles are applied to the treatment of the muscular paralysis wherever present, the weakened muscles being protected, not only from the force of gravity, but also from the deprivation of blood supply which follows on tight bandaging. As soon as tenderness has disappeared from the muscles massage may be commenced, the object in view being simply the improvement in the circulation of the paralysed muscles, so that on a recovery of function of the affected nerve cells and fibres, the muscles may be in such condition that they are able to respond to the stimuli which are sent to them.

Electrical stimulation of the paralysed muscles—which is only possible at first by the galvanic current—may easily do more harm than good if employed too long or too vigorously. The only advantage of electrical stimulation is the improvement of circulation, and an over-vigorous stimulation results in overstrain of the weak muscle fibres and in delay of recovery.

Considerable improvement can be effected by a well-regulated scheme of muscle training in the stage of recovery. The patient is taught to concentrate his energy and efforts on one particular movement which is carried out at first without, and later with, resistance. Treatment may thus be summed up under the following headings:

1. Prolonged recumbency which helps rapid recovery.
2. Warmth of the affected area.
3. Prevention of deformity and stretching of the paralysed muscles for at least 2 years.
4. Massage of the paralysed muscles when tenderness has disappeared.
5. Muscle re-education.
6. Support for residual paralysis when walking is permitted

Period of Recumbency. It is impossible to give any definite period for treatment in recumbency. Each case must be judged on its own merits; where the upper limbs only are involved, walking may be allowed in 6 months if the paralysed muscles can be effectively protected from strain.

With involvement of the lower limbs, or of the abdominal or spinal muscles, recumbency should be continued for at least 12–18 months. Recovery is more rapid and more certain when efficient physical treatment is given to a child in the recumbent position.

Deformity following infantile paralysis can be attributed to

1. Recovery of one or more muscles with paralysis of the remainder, the active muscles by their unopposed action producing the deformity.

2. Prolonged fixation of a joint in one position leading to a contraction of the soft tissues

These two factors frequently act in combination

Walking. When walking is permitted the paralysed muscles must be protected by some form of apparatus The aim of any apparatus is the prevention of deformity without compression and interference with the circulation of the paralysed muscles

The illustrations in Chapter II show the types of splint in general use in the ambulatory treatment of infantile paralysis. The principles to be followed in the use of such splints are simple; they must be so designed that they protect the paralysed muscles from strain while at the same time their application must not involve compression of the affected tissues.

Operative Treatment of Old Paralytic Deformities

The operations which are available in the treatment of paralytic deformities are of many types and may involve muscle, ligament or bone, according to the result desired. Occasionally it is possible to make use of an active or overacting muscle to replace the action of a

paralysed muscle or group of muscles. No definite rules as to the procedure can be given, and each case must be dealt with according to the condition found. If it is decided that improvement is likely to follow tendon transplantation, certain principles must be adhered to if success is to be gained. Thus:

1. The muscle to be transplanted must be sufficiently strong to produce the actioo required. For instance, if the palmaris longus muscle is active, while the flexors of the fingers are paralysed, the normal action could not he restored by transplantation of the palmaris tendon into the tendons of the fingers.

2. The transplanted muscle must act in a straight line from its origin to its insertion; no transplanted tendon can act round a corner.

3. The transplanted tendon must ha sutured into position under slight tension. If the tension is too great the muscle will not act, or the sutures will pull out. If the tendon is sutured without tension too much muscular effort is expended in producing tension before any effective action can take place.

4. If the transplanted muscle is inserted into the tendon of a paralysed muscle or muscles, the sutures at the point of union must not enclose the whole of the receiving tendon, otherwise this tendon rapidly loses its strength and stretches on account of the stoppage of its blood end lymph supply.

5. Transplantation of tendons must never be employed with the object of correcting a fixed deformity. The deformity must first be corrected before the tendon transplantation is performed.

6. If possible the transplanted tendon should be inserted into bone or periosteum rather than into the paralysed muscle or tendoo.

Stabilizing operations are frequently employed in the treatment of infantile paralysis. Thus, a shoulder, wrist, foot or an ankle which is flail may be improved functionally by an operation which diminishes or prevents movement. No special rules can be given for this type of operation, except the statement that stability will not follow unless bony union results, and all such operations should if possible be delayed until the patient has reached adolescence. Although any type of deformity may result from infantile paralysis and many different procedures may be necessary for their correction, the following are the more common deformities with their available methods of treatment.

Flexion Contraction of the Hip-joint

This very common deformity is usually the result of allowing the patient to sit up during the period of convalescence (Fig. 126). The tensor fascia femoris, ilio-tibial band, psoas and probably the anterior part of the capsule of the hip-joint become contracted. Full extension of the

FIG. 126.—Flexion of Hip-joint due to tight Tensor Fasciæ Femoris

joint is impossible, and if an attempt is made to straighten the joint passively the normal lordosis is greatly increased.

In its early stages the deformity may be corrected by gradual stretching. The patient should be placed on a frame or plaster bed on which the deformity can be gradually corrected by a combination of bandaging to the splint and the action of gravity. When the deformity is of long standing such procedures are, as a rule, ineffective, and the line of treatment to be adopted is as follows:

With the knee extended and the thigh adducted and rotated inwards so as to put tension on the contracted bands, the tensor fasciæ femoris and ilio-tibial band are divided by means of a tenotomy knife close to the anterior superior iliac spine and crest of the ilium. No attempt is made to lengthen the *deep contracted tissues, such as the ilio-psoas* muscle and the capsule of the hip-joint. The child is now fixed on a straight frame, which later should be gradually hyperextended, the affected limb being retained during the whole period of correction in its position of extension, adduction and internal rotation. Occasionally, if the patient has been placed in a position of hyperextension immediately after the operation, symptoms simulating those of an acute intestinal obstruction make their appearance after a few days. Vomiting is almost continuous and the patient appears very ill, while examination of the urine discloses the presence of a large quantity of acetone.

This complication, which is known as frame sickness, can be prevented by a slow correction of the deformity following on the operation. Thus, the patient should first be placed on a straight frame with a pillow under the head and shoulders; gradually the pillow is removed until the straight position is obtained. The frame may now be hyperextended, and this position may be assumed by the patient without danger. Similarly, if the frame sickness develops during the correction of the deformity, instant relief can be obtained by allowing temporary flexion of the legs, or by placing one or two pillows under the head and shoulders. As a rule, no further treatment is necessary, and the position of hyperextension can be resumed in a few days and must be maintained until the tendency to recurrence of the deformity has disappeared.

Soutter Fasciotomy. This more extensive procedure of the same nature is carried out by exposing the anterior aspect of the upper part of the thigh, dividing the ilio-tibial band and fascia lata and stripping off the muscular attachments on the outer aspect of the ilium as far down as the anterior inferior spine. In the more severe cases the ilio-psoas tendon, and even the anterior part of the capsule of the joint, are also divided. The anterior superior iliac spine, which would otherwise project under the skin, is now cut off flush with the surface and the skin incision sutured. The operation is unnecessarily extensive and is accompanied by a considerable risk to the patient's life, and for these reasons the simpler procedure of tenotomy and stretching is to be preferred. After-treatment is identical with that described following tenotomy of the same area.

Flexion Contraction of the Knee

Flexion of the knee with inability to extend the limb either actively or passively may result from prolonged fixation of the joint in a position of flexion, or the flexion may be associated with a more or less complete recovery of power in the hamstring muscles. Correction is usually effected easily by the slow, gradual stretching of the contracted muscles, using a bed knee splint (Fig. 1), or in the case of extreme deformity by the use of the two-way bed knee splint (Fig. 2).

Hyperextension of the Knee

Hyperextension of the joint usually results from recovery of the quadriceps group of muscles (Fig. 127), or the deformity may be caused by want of care in splintage during the treatment in recumbency following

FIG. 127.—Hyperextension of the Knee due to paralysis of Hamstrings.

the acute attack. Thus the position of rest for the paralysed thigh muscles should not be that of complete extension but should involve flexion of the knee joint to an angle of 15 degrees, thereby preventing

the overstretching of the posterior part of the capsule of the knee and of the paralysed hamstring muscles. Prevention of the deformity is simple and consists in the maintenance of the position of slight flexion of the joint during the whole period of treatment.

Treatment

When the deformity has occurred the weakened hamstring muscles and posterior capsule of the joint may be protected from strain by raising the heel of the shoe, so that in walking the knee is kept slightly flexed. Hyperextension may also be prevented by the use of a hinged knee cage, which restricts movements in any desired direction. Unfortunately the development of the thigh and calf muscles is hindered by the wearing of the cage, and where recovery in these muscles is still a possibility the use of the cage is contra-indicated In an attempt to improve the condition of the paralysed muscles massage and exercises should be continued for many months. Occasionally with extreme deformity of the joint such simple methods are insufficient, and improvement in function and in the stability of the limb can be obtained by a supracondylar osteotomy of the femur.

The object of the osteotomy is the provision of an angle anteriorly at the site of the osteotomy, thus compensating for the hyperextension of the joint. After dividing the femur just above the condyles the fracture *is set at such an angle that the lower articular surface of the femur points* backwards rather than directly downwards The leg is fixed in this position in a plaster case for 8–12 weeks until consolidation is complete, when walking is resumed, and considerable improvement in the line and function of the limb is to be expected.

Lengthening of a Limb

When gross shortening of one leg has followed on an attack of infantile paralysis the inequality of the limbs, which necessitates the use of a high surgical boot for walking, may be considerably reduced, or even eliminated by operative measures. This equalization in the length of the limbs is possible, either by shortening the long or normal limb, by destroying the growing epiphyseal plates in the normal limb at the upper end of the tibia and at the lower end of the femur, or by lengthening the shorter limb, either above or below the knee. Of these procedures the shortening of the normal limb, although the simplest, is rarely adopted because of the fear in the mind of the patient that the leg may not be as strong or as useful as before.

Lengthening of the limb may be obtained by operation on the femur or on the bones of the leg. The latter site is preferred for two reasons, the first because the proportion of the loss of length in the limb below the knee is usually much greater than that occurring in the femur, and

lengthening of the leg rather than of the thigh results in a more normal relationship between these two portions of the limb. Secondly, lengthening of the leg is a simpler problem than lengthening the femur.

Lengthening the Leg. In carrying out this operation a rigid, sliding frame is used in order that the lengthening may occur without displacement or rotation of the divided ends. Two pins are inserted through the upper portion of the tibia about half an inch below the epiphyseal line. Two similar pins are then put through the lower end of the tibia, a similar distance above the lower epiphysis. The tibia is now divided by a long oblique or Z-shaped split, and the fibula is cut through at two points, one near the upper and the other near its lower extremity. The pins are now fixed in the sliding frame in which distraction can be applied on the lower pins, the two upper being rigidly fixed, thus preventing traction on the knee-joint. Controlled by a scale marking on the frame, the lower portion of the tibia is pulled out about one-sixteenth to one-twelfth of an inch per day, the process involving little or no pain. Before any distraction of the limb is attempted, the leg should remain at rest in the frame for 48 hours. If this interval of rest is forgotten the extension process is usually so painful that the whole procedure must be abandoned. When the routine is followed correctly it is possible to obtain 2½ to 3 inches lengthening of the shortened leg, and when the desired amount has been obtained the limb should be fixed in a plaster case for 8 or 10 weeks until consolidation is complete.

Lengthening of the Femur. Lengthening the femur is a more difficult procedure, as the traction at either end of the bone can be applied only through one pin, the upper being inserted at right angles to the lower. At the upper end of the femur the pin must pass from before backwards, while that at the lower end is placed horizontally, thus complicating the extension and preventing smooth traction. The lengthening obtained in this way in the femur is less than that possible in the tibia, and if full length below the knee is obtained, operation on the femur is usually unnecessary.

Epiphyseolysis. As an alternative to lengthening the short leg the difference in length of the limbs may be reduced by the operation of epiphyseolysis. In this procedure the epiphyseal plates at the lower end of the femur and the upper end of the tibia of the normally growing limb are destroyed or removed by operation. This destruction of the two chief growing points in the limb prevents to a large extent the increase in the difference in length of the limb, and if the operation is carried out about the age of 10 or 12 years the eventual shortening of the affected limb may be very slight. The object of the operation is the early fusion of the epiphysis to the diaphysis, which inevitably follows the removal of the epiphyseal plate of cartilage.

PARALYTIC DEFORMITIES OF THE FEET

Talipes Equinus

This deformity, which is in reality caused by contraction of the calf muscles, is commonly described as contraction of the tendo achillis and is seen more frequently than any other following infantile paralysis. Its occurrence may be to some extent inevitable, when it is due solely to the absence of recovery in the extensor group of muscles, but more commonly it results from want of care of the paralysed muscles during the active and convalescent stages of the disease, the action of gravity and the weight of the bed-clothes having caused dropping of the fore-foot and mechanical overstretching of the paralysed extensor muscles combined with contraction of the recovered flexor group.

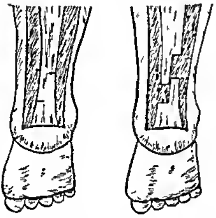


FIG. 128.—Tenotomy of Tendo Achillis

The deformity is easily corrected by the closed elongation of the tendon, in which division is made by a tenotomy extending half-way through its substance on each side, with an interval of 1½–2 inches between the divisions. Stretching of the foot into dorsiflexion produces the necessary sliding of the two portions of the tendon and allows the foot to come into the desired position of correction (Fig. 128) This corrected position is maintained by the fixation of the foot in a plaster cast for a period of 8 weeks, following which the use of the foot is permitted, and recurrence of the deformity prevented by the use of a right-angled foot splint at night. When walking is resumed the patient should wear only flat-heeled shoes which continue the stretching of the contracted muscles at each step. Stretching of the calf muscles by dorsiflexion of

the foot, combined with massage of the weakened anterior group, must be continued until all possible improvement has been obtained.

Tendon Transplantation in Paralysis of the Foot

Although at one time used almost invariably in the treatment of paralytic disabilities of the leg and foot, the operation of tendon transplantation is now employed only in certain defined conditions. Before tendon transplantation can be employed the surgeon must be assured that the muscle whose tendon is to be used is sufficiently strong to perform the desired action, and secondly, that the removal of the muscle from its normal position will not be followed by a secondary deformity. These two conditions are answered in paralysis of the peronei muscles, where the active tibialis anticus and posticus muscles are forcing the foot into adduction and inversion, and considerable improvement in the appearance and usefulness of the foot follows on the transplantation of the tendon of the tibialis anticus muscle to the outer aspect of the metatarsus.

The operative technique is as follows.

Two small incisions are made over the tendon, one over its lower attachment, through which the tendon is divided at its insertion into the bone, and the other over the course of the tendon, about 3 inches above the ankle-joint; through this incision the divided lower end is pulled on to the surface. Another incision is then made over the space between the bases of the 3rd and 4th metatarsal bones, and, after passing the tendon subcutaneously from the upper incision, it is threaded through this space and sutured into the roughened bony tissue of these metatarsals. The foot is now fixed in dorsiflexion and slight eversion for 6–8 weeks, when active use and training without weight-bearing will improve the control of the transplanted muscle and obviate the use of any irons or retentive apparatus. Temporary support of the foot should be given at night by means of a right-angled foot splint, thereby preventing the overstretching of the transplanted muscle.

The operation of transplantation of the peroneus longus tendon to the inner side of the foot, with the object of replacing the action of the paralysed tibial muscles, has been abandoned, the results of the operation when performed as a single procedure, and not as a part of a stabilizing operation on bone, being highly unsatisfactory.

Dunn's Operation for Stabilization. For more extensive paralytic deformities of the foot and leg, where instability is the outstanding feature, the stabilizing operation described by Dunn is of considerable help. This procedure has as its object the fusion of the sub- and pre-astragaloid and calcaneo-cuboid joints, leaving the ankle-joint to perform the normal range of antero-posterior movements, but obviating the twists and deformities which previously occurred below and in front of the astragalus. The operation is performed preferably after the age of

12-14 years, when the tarsal bones have become more fully ossified and bony union occurs readily.

Through an incision on the outer border of the foot the adjacent articular surfaces of the os calcis and cuboid are removed; the neck

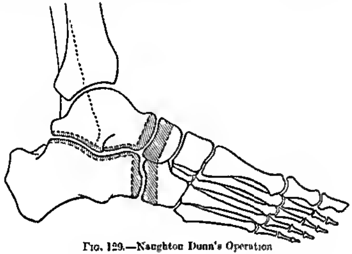


FIG. 129.—Naughton Dunn's Operation
(a) Showing amount of bone removed.

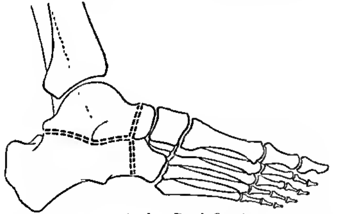


FIG. 129.—Naughton Dunn's Operation.
(b) Showing foot in position following operation with heel displaced backwards.

of the astragalus is then divided behind its anterior articular surface, and this and the posterior half of the scaphoid are removed. The articular and interosseous surfaces of the astragalus and os calcis, together with their interosseus ligament, are then removed and the foot displaced backwards on the astragalus (Figs. 129a and 129b). If the tibialis posticus

or peronei, or even the long flexor muscles of the toes, are, by their over-activity, causing deformity, they may with advantage be at the same time implanted into the tendo achillis.

After displacement of the foot backwards the whole leg and foot are fixed at right angles in the neutral position in a plaster case for a period of at least 4 months, to allow union to occur at the original sub-astragaloid and pre-astragaloid and calcaneo-cuboid joints. When consolidation is complete no retentive splint is, as a rule, necessary, and walking in a normal shoe may be instituted forthwith. If the consolidation is doubtful, the use of an inside or outside iron, combined with a night splint, may be of advantage for a time.

Operative Procedures on the Upper Limb

Paralysis of the Shoulder Girdle

For this very common disability arthrodesis of the joint may be performed, but its employment is only advisable under certain conditions.

1. The scapula must be freely movable on the chest wall.
2. The muscles governing the scapula must be strong and active, so that the united scapula and humerus may be moved in one piece.
3. The muscles governing the elbow and hand must be active and strong. With complete, or almost complete, paralysis of the arm ankylosis of the shoulder is a disadvantage rather than a help.

If these conditions are present, arthrodesis is usually advisable in children and adolescents, where the mobility of the scapula permits a useful range of movement in adduction and abduction. In the adult the advisability of arthrodesis is often questionable, and, whilst there is increased stability, there is the disadvantage of loss of every form of passive movement of the joint. This may not seem to be of much importance, but in women especially the loss of rotation is very often complained of bitterly following a successful arthrodesis. The technique of this operation has already been described in Chapter X.

INFANTILE PARALYSIS OF THE TRUNK

Paralysis of the Abdominal Muscles

This disability is readily recognized by the abnormal prominence of the abdomen, especially when the patient is standing, and by the inability to contract the abdominal wall. When the paralysis affects only the abdominal muscles, sufficient support to the paralysed muscles is given by a suitable abdominal belt, whose use may in time lead to considerable improvement and lessening of the paralysis.

Operative Treatment. When only one side of the abdominal wall

is paralysed the operation of Lowman, which entails the implantation of a broad strip of fascia lata between the crest of the ilium and the 10th rib on the affected side, has been tried with the object of preventing the development of a secondary scoliosis. The operation is justifiable if the correction cannot be maintained by the use of an abdominal belt.

Paralysis of the Glutei Muscles

Paralysis of these muscles, if bilateral, presents an extremely difficult problem in locomotion. No suitable form of splint has been devised to give support to the hip in the extended position, and at the same time to allow flexion at the joint. As a rule, when both groups of gluteal muscles are affected there is also very extensive and widespread paralysis, and the problem of the glutei muscles is only one of a series which usually includes paralysis of both thighs and legs. Attempts to replace the action of the glutei by a portion of the erector spinæ muscle have proved to be on the whole unsatisfactory.

No form of ambulatory treatment is entirely satisfactory; the best support is undoubtedly given by means of crutches, combined with the use of caliper splints.

PARALYTIC DEFORMITY OF THE SPINE

This condition has already been dealt with in Chapter XIV.

CHAPTER XVIII

SPASTIC PARALYSIS

(Cerebral Paralysis of Children)

Following an interruption in any portion of the upper motor neuron system a condition of hypertonicity of muscle develops in the affected area, the reflexes are exaggerated, and attempted voluntary movements are completed in an inco-ordinated and jerky fashion. According to the site and extent of the lesion, the muscular inco-ordination may be confined to one limb, to the arm and leg on the same side. to the two lower limbs, or may embrace all four limbs, the clinical conditions arising from these affections being described as monoplegia, hemiplegia, paraplegia or quadriplegia respectively. The causative nervous lesion results from injury or disease, either of which may affect the central nervous system before, during or after birth.

Types of Causative Lesion

Ante-Natal. Injuries to the upper motor neuron system occurring before birth must be extremely rare, but instances of absence of development of part of the cerebral cortex, or of some portion of the pyramidal tracts, have been described, while ante-natal syphilitic affections may also destroy the cell or its neuron.

At Birth. Injuries occurring at birth are responsible for the great majority of cases of spastic paraplegia. These injuries to the nervous system are more likely to occur at this time if the labour is prolonged and difficult, if forceps have been used, or if the child is subjected to prolonged asphyxia. Any part of the central nervous system may be injured, but the cerebral cortex, the corpus striatum and the basal ganglia are the common sites of injury

Post-Natal. After birth the central nervous system of the child is more frequently affected by inflammatory conditions and disease than by injury. Hæmorrhage, meningitis, hydrocephalus and syphilitic affections may each produce localized changes, which are often followed by degeneration in the pyramidal tracts and in the lateral columns of the cord, the affected nerve fibres and ganglion cells being converted into an undifferentiated mass of gliosis.

Clinical Picture

In any type of spastic paralysis the muscles of the affected limb, or limbs, are in a state of exaggerated spasm, resulting in the development of deformities which are still further increased by any effort at voluntary movements. The deformities develop owing to the inequality of strength

of the opposing muscles acting on a joint, the stronger group overcoming their weaker antagonists, and the limbs being drawn into abnormal positions. The most typical deformities are seen in paraplegia, where the thighs are held closely together, the hips flexed and internally rotated, while the knees are bent and the feet plantar flexed. These deformities are still further increased if the patient makes a voluntary effort or is excited, while the excessive muscle spasm can be demonstrated by suddenly jerking the child, when the limbs are seen to cross each other and the feet to become more acutely plantar flexed. Because of the loss of control of the muscles, standing without support is impossible, and the inability to balance is often increased by the presence of involuntary twitching movements which only disappear during sleep.

When the upper limb is affected the arm is adducted to the side, the elbow slightly bent with the forearm firmly held in full pronation. The hand also shows considerable deformity, being flexed at the wrist and deviated towards the ulnar border, the thumb being flexed across the palm, where it is usually held by the flexed fingers.

In paraplegia the mental development is, as a rule, considerably retarded. The child, in fact, often appears to be even less intelligent than is really the case, on account of the difficulty experienced in enunciation. In the more severe type of the disease, dribbling at the mouth and absence of control of the bladder are frequently prominent signs which distress the parents and make any attempt at relief of the deformities more difficult.

Effect of Correction of Deformities. The mental condition of the child suffering from paraplegia is, to some extent, governed by its physical condition. Where the mentality is sufficiently advanced to justify correction, improvement in the mental state frequently follows on successful treatment of the deformities, and after an improvement in muscular control the child's mental powers seem to develop rapidly.

Treatment

Indications. Treatment of the deformities should not be undertaken in every case. Unless the child is intelligent and can co-operate, any corrective treatment will only retard progress and will increase the abnormal muscle spasm. On the following considerations should be based the decision as to the advisability of treatment:

1. The child must be sufficiently intelligent to understand all that is being said, in order that it may co-operate in treatment.

2. If the child suffers from persistent bed-wetting, corrective procedures are definitely contra-indicated until this condition improves.

3. Persistent dribbling at the mouth should be considered as a sign of backward development and loss of control, indicating a poor prognosis.

4. The presence of athetoid movements in the affected limbs may also be taken as a definite contra-indication to operative treatment.

As a rule, if any of these four clinical signs are present, operation of any kind should be postponed to a later date, because such patients cannot carry out the necessary exercises and voluntary movements which form an important part of after-treatment. This postponement of surgical treatment does not mean its abandonment, as an interval of complete rest from all forms of treatment is often followed by the disappearance of some of these unfavourable signs and an improvement in the patient's general condition.

In no branch of surgery are patience, care, and enthusiasm more fully rewarded than in the treatment of spastic paralysis. As previously noted, in many instances the patient's mental powers are much greater than would appear on the first examination. Before starting any type of treatment every effort must be made to gain the patient's confidence. Exercises with or without the help of a musical accompaniment are of the greatest value in helping the patient to relax. These exercises are at first carried out simply by the patient and only when some progress has been made, should the treatment advance to the stage of manipulative correction of the deformities.

Many efforts have been made to reduce the abnormal muscular tone by the use of drugs and of these Prostigmine has been the most successful. Following its first administration there is frequently considerable decrease of the muscular tension, but prolonged use of the drug does not, as a rule, improve the condition.

Stretching. When the contractions are not extreme and the child is mentally bright, simple stretching of the contracted muscles may be sufficient to produce a decided improvement in control. In dealing with the lower limbs the adductor group of muscles should first be stretched and the thighs rotated outwards; then the calf muscles are lengthened by passive dorsiflexion of the feet, and the hamstrings stretched by straightening the knees. Fixation of the limbs in the corrected position should be continued until the spasm has largely disappeared, retention in the corrected position at night being advisable as a precautionary measure for several months.

For the more severe degrees of the disease simple stretching of the affected muscles is insufficient, and reduction of the spasm and correction of the deformities can only be obtained by

Operative Treatment. The various operative procedures available may be grouped into four classes:

1. Division of posterior spinal nerve roots (Förster).
2. Operations on sympathetic nerves (Royle).
3. Operations on efferent nerves (Stöffel).
4. Operations on muscle.

These four methods, in each of which the problem of excessive muscle

spasm is attacked from a different angle, have been very extensively used, and certain conclusions may be drawn from the results observed.

1. As the central inhibitory control of the muscles has been lost by the destruction of part of the upper motor neuron, an attempt was made to diminish the excessive muscle spasm and to increase the voluntary control by division of some of the posterior roots of the nerves supplying the affected limb. As it would obviously be impossible to divide all the posterior roots of the nerves supplying the limb without causing a complete anæsthesia, the division of half of these roots was carried out, and, although the operation was followed by some diminution of the excessive spasm, there was no corresponding increase of voluntary control of the affected muscles.

2. *Royle's operation* of division of the grey rami communicantes, passing from the sympathetic nervous system to the motor nerves supplying the affected muscles, is based on the theory that the abnormal spasm in these muscles results from the presence of non-medullated fibres from the sympathetic nervous system, through which the tonic muscle spasm was thought to be controlled, the voluntary muscle contractions being governed by stimuli from the motor fibres. It is probable that the theory of this extra innervation is unfounded, and the results obtained by this method of treatment have been so poor that it now receives little support.

3. *Stöffel's operation* consists in the division of some portion of the motor fibres which supply each of the contracted muscles, the object of the operation being the reduction of the spasm in that muscle. Unfortunately it is not possible to gauge the exact amount of nerve tissue which should be divided, and instances of too restricted and too free division are common.

4. In this method an attempt is made to equalize, as far as possible, the power exerted by the opposing groups of muscles which act on each joint of the affected limb.

The stronger groups of spastic contracted muscles are weakened by their complete or partial division in order that their opponents may act to better advantage, the object of the treatment being the restoration of the balance of power between the opposing groups of muscles. The persistent adduction deformity of the thigh can be overcome by weakening the pull of the adductor muscles, which are first put under tension by abduction of the limb, and then divided by a tenotome close to their origin from the pelvis. The hamstring muscles are seldom sufficiently tight to require lengthening; very occasionally, in the presence of a severe flexion deformity of the knee, the tendons of the semitendinosus and gracilis muscles may be lengthened by a Z-shaped division performed through an incision in the popliteal space. It is necessary only to weaken and not completely divide these tendons, and it must be remembered

that under no circumstances should the semimembranosus tendon be divided or elongated.

Equinus Deformity. This deformity, which is always present in spastic paraplegia, must never be treated by complete division of the tendo achillis, because of the danger of producing non-union between the widely separated ends of the divided tendon. If possible, the contracted calf muscles should be stretched by forcing the foot above right angles and fixing it in this over-corrected position in a plaster case, but if the muscular contraction is so great that the foot cannot be forced into the desired position, the tendon should be lengthened by open division and suture.

Through a lateral incision, 4–5 inches in length, the tendon is split along its centre, and divided through half its substance on opposite sides at the upper and lower ends of this incision. The foot should then be brought to right angles by sliding the two halves of the tendon between the cuts, after which the two portions of the divided tendon are sutured firmly together. Fixation of the foot at this angle is continued for 8 weeks, when use without protection is permitted, recurrence of the contraction being prevented by the continued use of a right-angled foot splint at night.

Correction of the Internal Rotation of the Thigh. Internal rotation of the thigh is occasionally extremely persistent in spite of continued stretching, and the deformity may be disabling even when all the adduction has been corrected. The cause of the rotation is to be found, as a rule, in the over-action of the anterior portion of the gluteus medius muscle. This can be felt as a tight band in front of the upper end of the trochanter, especially when an attempt is made at passive external rotation of the hip.

Correction of this deformity is comparatively easy, the tendon of the gluteus medius being divided close to its insertion into the great trochanter, the operation being performed through a vertical incision made over this region.

After-Treatment

When the deformities have been corrected, either by stretching or by division, after-treatment must be carried out conscientiously if improvement in function is to be obtained. The child should be fixed on a frame, with the legs widely separated and the thighs externally rotated, the knees being kept straight and the feet maintained at right angles in foot splints or in plaster casts. This position is maintained for 4 weeks, when the child can safely be removed from the frame and the limbs exercised. The retention of the feet at right angles must be continued for at least 8 weeks before allowing full use of the limbs. The period of fixation is followed by the more important stage of restoration of function, the child is encouraged to stand, confidence being given by adequate

support which is gradually diminished as the power of movement returns. Exercises of a selective type should be encouraged, each limb and each joint should be used separately, the object of training being the development of control rather than the development of muscle strength.

When the child begins to walk the knees should be kept fully extended by the application of straight splints, which are removed as soon as the walking exercise is finished. If flexion of the knees is allowed in the early stages of walking a severe calcaneus deformity of the foot may develop, owing to the overstretching of the unsupported posterior capsule of the ankle-joint. In 2–3 months all fixation may be removed and complete freedom permitted, but the use of right-angled foot splints at night should be continued for at least another 3–4 months.

HEMIPLEGIA

The Lower Limb. In hemiplegia the deformity in the affected lower limb is identical with that seen in paraplegia, the mental condition of the child is usually better than that of the paraplegic, and treatment of the same type can be undertaken with confidence.

The Upper Limb. Here, the cause of the deformity is the same as that of the lower limb; all the muscles are contracted in a tonic spasm, the position assumed by the limb being the result of the greater power of the flexor as compared with the extensor groups. The wrist is flexed and is usually deviated towards the ulnar border with the fingers extended at the metacarpophalangeal and flexed at the interphalangeal joints. The elbow is flexed to right angles and the forearm is fixed in pronation, full supination, either active or passive, being resisted chiefly by the shortened pronator radii teres muscle.

Treatment

When the deformity is comparatively mild and the muscular contraction is not excessive, considerable improvement in function may be obtained by moulding the forearm into supination and the wrist into dorsiflexion, and fixing the limb in this position for at least 6 weeks. The corrected position is maintained until the spasm has diminished, this period of stretching being followed by exercises designed to develop the movements which were previously absent. In order to prevent recurrence of the deformity the reapplication of the corrective splint at night should be continued for several months.

In the more severe contraction, when correction of the deformity by moulding is impossible, the power of supination may be restored by weakening the excessive action of the pronator group of muscles. To

do this the tendon of the pronator radii teres should be divided close to its radial insertion.

Operation. Through a vertical incision over the outer border of the radius, just above the middle of the bone, the tendon of the pronator radii teres is defined as it lies under the tendon of the supinator longus. The whole of the tendon of the pronator radii teres is stripped off the radius and the forearm supinated. After-treatment follows closely on that used in simple stretching of the tendon, and definite improvement of function can be expected.

Flexion of the Wrist. Flexion of the wrist can be diminished and the use of the fingers and thumb improved by the application of a short wrist splint (Fig. 11), which retains the wrist in slight dorsiflexion and permits the free use of the fingers and thumb. The use of the splint should be continued for at least 3–6 months, when it may be gradually removed, being reapplied at night only for another 6 months.

CHAPTER XIX

PERIPHERAL NERVE INJURIES

Peripheral nerves may be injured by many types of direct and indirect trauma, the most obvious being through the medium of a penetrating wound, in which the nerve may be divided partially or completely. Injury to the nerve may also occur as a complication of a simple fracture, the nerve either being torn over a sharp bony spike, or, if uninjured at the time of the fracture, its continuity may be lost at a later date through the development of an organizing scar in the surrounding tissues.

The radial, ulnar and external popliteal nerves, which lie close to the surface, are particularly prone to injury by bruising or crushing, and severe damage to their constituent fibres may be caused by continued friction of the nerve over a bony prominence. The function of a nerve, which is the conduction of impulses either from the central nervous system to the periphery or in the reverse direction, may be lost either with or without an anatomical interruption in its fibres.

For this reason nerve lesions may be grouped into two main divisions:

1. Physiological lesions, in which the nerve function is lost without interruption in the continuity of its filaments or of its enclosing sheath.
2. Anatomical lesions characterized by a definite interruption in the substance of some or all of its fibres.

PHYSIOLOGICAL LESIONS

In this group, to which the title of nerve concussion is also given, injury to a mixed nerve is followed by loss of power, either partial or complete, in the muscles supplied, while at the same time sensation is lost over its sensory distribution. The loss of sensation is, as a rule, incomplete, and the area of anæsthesia does not exactly correspond with the area of skin supplied by the injured nerve. Although the muscles supplied by the injured nerve show no power of voluntary contraction, they do not, as a rule, become atrophied, and their response to faradic stimulation is retained during the whole period of their functional inactivity. Return of some voluntary power occurs within a few days or weeks, and restoration is usually complete within 3–4 months. Occasionally, however, if the injured nerve has become involved in scar tissue, these signs of concussion are replaced by those of compression owing to contracture round the site of injury.

Compression of a nerve may be the result of pressure from outside the body, as in the case of crutch paralysis, in which the radial nerve

is compressed against the upper and inner side of the humerus, producing the typical crutch palsy with loss of power of extension of the wrist and fingers. Or similar signs can follow the constriction of the nerve in a mass of scar tissue following on extensive soft tissue lesion. Very occasionally the pressure of callus round the site of a healing fracture may form the constricting agent, although in most instances the nerve retains its function, even when surrounded by a large mass of callus.

Signs and Symptoms

The signs and symptoms which are caused by compression are usually identical, whether the originating cause be from an external source or from within the body. Neuralgic pains of varying severity, cramps and muscle spasm appear early and steadily increase. Sensation is partially lost over the area of distribution, while the affected muscles lose power, although always retaining some degree of voluntary activity.

Nerve irritation may follow on any type of injury to the nerve itself or to its neighbouring tissues, the symptoms varying with the severity of the lesion, from tingling and tenderness along the affected nerve trunk to a condition described as causalgia, in which pain is practically constant, and is increased by any movement of the limb or by changes of temperature, or pressure on the nerve or on its area of skin distribution. As with the pain and tenderness, the cutaneous signs also vary with the severity of the lesion from a slight dampness to a profuse sweating over the whole extent of the area supplied.

True causalgia is as a rule found only when the original nerve injury or any subsequent surgical intervention has been complicated by infection. Sections from a nerve affected in this way demonstrate a widespread infiltration of fibrous tissue between the fibrils, some of which show signs of degeneration. In true causalgia the pain is often so severe that the patient refuses to move the limb or to have it washed or touched. His general condition rapidly deteriorates, as a result of loss of sleep, and in some recorded cases self-destruction has been preferred to constant agony.

ANATOMICAL LESIONS

The injury sustained by a peripheral nerve in the substance of a punctured wound may be complete or incomplete, while those occurring as complications of a fracture or dislocation are, as a rule, incomplete.

The Signs of Complete Division of a Mixed Nerve can be summarized as follows:

1. *Loss of Voluntary Power in all the Muscles supplied by the Injured Nerve.* The affected muscles show a steadily increasing atrophy, the diminution in size being caused by the degeneration of some or all of the muscle fibres and their replacement by fibrous tissue.

2. *Alterations in Electrical Reactions of the Affected Muscles appear rapidly.* The normal reaction of the muscle following stimulation by the faradic current is lost in 24–72 hours, while the response of the muscle to galvanic stimulation is considerably altered, the muscular contraction resulting being irregular and frequently localized to one part of the muscle stimulated. In 2 or 3 weeks a change is noticed in the polar response to galvanic stimulation. Normally the muscle contracts more fully and rapidly with the cathodal closing current, but this gradually alters until the anodal closing current produces a more powerful contraction. This condition of loss of reaction to faradic stimulation and change in the polarity of galvanic stimulation is described as the reaction of degeneration, and can be taken as a sign of an anatomical division of the nerve fibres If the muscle degeneration continues, the galvanic response is eventually lost also, owing to the complete replacement of muscle fibres by fibrous tissue.

3. *Sensory Changes.* Complete anæsthesia in the area of skin supplied solely by the injured nerve, the loss of sensation involving both fine touch and pin-prick. Round the edges of this area of anæsthesia there is often found a ring of marginal hyperæsthesia in the area receiving a double supply from the injured nerve and from its uninjured neighbour.

4. *Vasomotor and Trophic Changes* are shown by the affected cutaneous area becoming smooth, dry and shiny, the normal skin creases tend to disappear, while in the fingers the loss of subcutaneous tissue produces a tapering, spiky appearance. Ulceration of the affected area is commonly present with complete anæsthesia, but is not caused solely by the loss of sensation, but by a combination of anæsthesia and external irritation or injury.

Signs of Incomplete Division

With an incomplete lesion some of the changes just described are present, while in other areas supplied by the affected nerve the reactions are normal. Thus, some of the affected muscles may show the reaction of degeneration, while in others the response to electrical stimulation may be normal. Sensory loss is not complete, and sensation may be present in part of the area supplied, while the trophic changes are, as a rule, minimal, or may be present only in a localized area.

Treatment of Nerve Injuries

Efficient treatment can only be based on a correct diagnosis, which should if possible be established before treatment is undertaken. Although it is not always possible to differentiate between a partially divided nerve trunk and one in which pressure of external scar is producing a partial loss of function, a decision must be reached as to the presence of a physiological or an anatomical lesion. With a physiological division

recovery takes place without any active surgical or physiotherapeutic measures. Rest and warmth of the affected limb are sufficient to hasten the inevitable recovery.

Nerve compression and nerve irritation, although producing different syndromes, can be considered as one problem from the point of view of treatment. They are each due to abnormal local conditions, either in the nerve itself or in the neighbouring tissues, and the question of the advisability of conservative or operative measures in treatment depends to a large extent on the severity of the symptoms. It is advisable in either of these conditions to postpone operation until examinations, repeated at intervals of a month, have demonstrated that the nerve involvement is increasing or is showing no signs of improvement. During the period of waiting considerable benefit can be secured by physiotherapeutic treatment; paralysed and stretched muscles should be relaxed by splinting or bandaging, and local circulation can be improved by heat and massage.

If it be decided as a result of careful re-examination that a true anatomical division of nerve fibres is present, no time should be lost in performing the necessary operation. An operation of inspection in the hands of a competent surgeon is never harmful and is often of the very greatest advantage to the patient. More harm is done by unnecessary waiting than by a simple exploratory operation, even when the condition found at the time of operation is not sufficient to explain the loss of function. It is better to err on the side of early operation rather than subject tha patient to unnecessarily prolonged conservativa treatment.

Treatment of Causalgia

The prognosis in this condition, and the treatment available, differ so greatly from that of all other types of nerve injuries that it is advisable to consider it as a separate entity. Occasionally the affected nerve can, with advantage, be freed from pressure of the surrounding scar tissue and placed in a scar-free intermuscular bed, but as a rule the operation is not followed by any relief of symptoms. After one attempt no further operation of a similar type is advisable; even a wide exsection of the affected area of the nerve does not as a rule lead to any diminution of the symptoms, and amputation of the limb at a higher level may be suggested by the patient. As this heroic treatment often fails to relieve, it should only be undertaken as a last resort and with the patient's realization of the possibility of failure. Electrical stimulation, radiant heat, baths and massage do not as a rule afford any relief, although on occasion some alleviation has been obtained by the use of anodal galvanism.

The most satisfactory treatment consists in maintaining complete immobility of the area, which should also be protected from injury and from changes in temperature. The affected limb should be lightly bandaged over a layer of wool and immobilized for an indefinite, but

usually prolonged, period. Following this line of treatment, relief, though always slow, is the rule, and as the patient is usually anxious to continue, complete alleviation is often obtained.

Ganglionectomy. The operation of ganglionectomy has in many instances given complete relief of causalgia when all other methods have failed. Certain conditions must be present if success is to be obtained. The prognosis is poor if the causalgia has been present for several years, the results in these cases being so poor as to make the operation inadvisable. A definite indication of the probable success of the operation can be obtained by the injection of Novocain into the stellate ganglion; if the pain disappears following the injection, permanent relief will almost certainly follow ganglionectomy.

Recent Nerve Injuries

If a nerve lesion is discovered in an open wound, primary suture should never be undertaken if there is any possibility of wound infection. It is advisable to delay suture until all risk of this complication has disappeared, when secondary suture can be effected with safety and without risk of the occurrence of the intense hyperæsthesia or causalgia which so often follow infection at the line of suture.

If the divided nerve is seen during the course of débridement of an extensive wound of the soft tissues, the secondary operation is made more simple by approximating the ends by one loosely tied suture inserted through the sheath. At a later date, without the risk of infection, the routine end-to-end suture should be undertaken; the delay of one or even two months—which is involved in this routine—does not unduly delay the recovery of function and should not weigh against the risk of infection The interval between the cessation of infection in the wound and the performance of any necessary operation on the nerve depends on the tissues involved. If the nerve lesion is associated with a compound fracture, no operation should be considered until all trace of infection has disappeared for at least 3 months, while if bone is not involved the period may be shortened to 4 or 5 weeks. During the last 3 weeks of this period of waiting the wound should be subjected to heat and massage, in an effort to bring to light any septic focus which may be localized in the depths of the wound, and which could be the cause of infection at the subsequent operation.

Operation. A long incision is made over the course of the injured nerve, extending well above and below the probable site of injury. The undamaged portions are first identified above and below the lesion and followed from these points towards the suspected area. By following the nerve in this way from the normal tissue on either side it is comparatively easy to identify it through its whole course, but if approached directly through a mass of scar tissue identification is usually impossible and

entails a considerable degree of trauma. In completing the dissection the nerve may be raised from its bed by flat elevators passed under it above and below the injured area, thus allowing the dissection to be completed without injury to its trunk. When the nerve is freed from the surrounding scar the exact nature of the lesion can be appreciated and dealt with. The following are the types of injury usually encountered:

1. Complete division.
2. Lateral fibroma.
3. Central fibroma.
4. Division of nerve fibres with continuity of sheath.
5. Lateral adherence to scar.
6. Involvement of nerve in scar mass.

Complete Division of Nerve Trunk. When the divided nerve ends have been freed from the surrounding tissues it will be seen that, on the central end, appears a rounded neuro-fibromatous tumour, while the degenerated distal segment shows no such mass, although occasionally a small rounded neuroglial cap is present. In order to be successful the surgeon must aim at bringing together the healthy freshened nerve ends free from scarring, and joining them in approximately their normal alignment. This freshening of the nerve-ends can be completed satisfactorily by grasping with the forceps the sclerosed ends of each segment which, on account of its structure, cannot conduct impulses and must be removed. While the nerve is steadied in this manner the trunk is cut through half its substance at the base of the terminal fibroma; if healthy fibres—indicated by protruding bundles and often by bleeding—are not seen, further similar cuts are made at intervals of one-sixteenth of an inch away from the lesion until satisfactory conditions are encountered. The distal end of the nerve is similarly prepared, the only difference being that the protrusion of the nerve fibres is not so definite as in the proximal segment, owing to the degeneration which always occurs in the nerve fibrils and in the sheath. The prepared nerve ends should now be joined by suture of the cut nerve sheaths, the suture material used passing through the sheath only and not through the substance of the nerve.

By experiments on animals Young has shown that around each suture there is developed a localized area of inflammation and later fibrosis; the amount of the inflammatory reaction depends on the nature of the suture material Very fine silk sutures produced the least reaction, while the use of catgut was followed by considerable scar formation at each suture point. In these same experiments it was also discovered that, if the divided nerve ends were stuck together by a non-irritating adhesive material, in this case fibrino-plastin, this inflammatory reaction could be eliminated, while the rate of growth of the

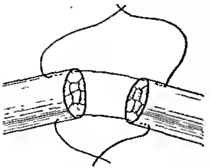


Fig. 130.—Suture of a nerve, showing sutures inserted through the nerve sheath only.

divided fibres was *slightly accelerated* when fibrino-plastin was used as compared with the sutured nerve. The use of fibrino-plastin as a suture material is unfortunately only possible in *experimental work*, as considerable tension is often present between the divided and sutured nerve ends

Fine silk or linen thread sutures can be used with safety and should be inserted through each end of the nerve, as in the diagram (Fig. 130) *After joining the ends a new healthy* bed should be provided, preferably between two neighbouring muscle bellies, the unbroken perimysium forming the best possible prevention against the subsequent formation of adhesions. The use of loose or pedunculated fat or fascial flaps to *cover the line of suture has been discarded, as these flaps did* not prevent pressure and adhesions round the line of suture, but by their conversion into scar tissue they made these complications inevitable.

Until recovery of function the paralysed muscles must be protected by splinting against the overstretching which follows on the unbalanced action of their opponents. By massage and weak electrical stimulation the circulation can be improved and the muscle fibres maintained in a condition suitable for the resumption of activity when nerve function has been restored.

Central and Lateral Fibromata. In addition to their difference in situation these tumours differ also in structure The central fibroma is almost invariably composed of connective tissue, derived in most instances from the organization of a hæmatoma. The *lateral fibroma* may consist of a similar mass of connective tissue, or may be a pure neuroglial tumour, projecting from the side of the nerve trunk. Although a neuroglial tumour may be present without producing symptoms or signs of interference with conductivity, fibromatous masses in the substance or attached to the side of a nerve are usually associated with an injury to a certain proportion of the neighbouring nerve fibrils. The decision as *to* the advisability of active surgical repair of the involved nerve depends on the extent of the replacement of the nerve fibrils by scar tissue and on the proportion of nerve fibrils which are still active.

If it is decided that repair of the nerve is necessary, operation is undertaken after a complete investigation of its sensory and motor *functions. When the nerve* has been *exposed* at operation further examination is possible. Two more exact methods of testing its conductivity are then available; the first consists in direct stimulation of

the nerve above the site of lesion with a sterile electrode and recording the muscular response. This method is not always entirely reliable, as the nerve immediately after being freed from pressure may fail to conduct stimuli which would pass after an interval of rest. The second method of mechanical stimulation of the nerve, by light touches above the lesion, is much simpler, and is as reliable as electrical stimulation; both methods are of value, but the final decision as to the procedure to be adopted must be based on a careful weighing of all the different types of examination.

A decision as to the probability of recovery of function in the injured nerve is helped by digital examination at the site of the lesion. When the nerve is palpated the consistence of the tumour can be appreciated. If, before operation, clinical examination has indicated serious interference in function, and on palpation a strong hard lump can be felt in its substance, it is unlikely that any improvement will follow conservative measures. Under such circumstances, the whole of the affected segment should be excised and the divided ends joined together. When the tumour is soft, and especially when previous clinical investigation has indicated a comparatively mild lesion, improvement often follows the transference of the nerve trunk into a healthy intermuscular bed.

The operation of neurolysis, or splitting of the nerve sheath, in an effort to relieve pressure in the affected area, is of no practical value, as pressure could arise only from the conversion of the sheath into fibrous tissue, and splitting this fibrous mass leads only to an increase of its substance and an exaggeration of its pressure effects.

Division of Nerve Fibres with Continuity of the Sheath. This type of injury occurs most commonly as a complication of fractures or dislocations, although it is evident from clinical examination that the nerve function is completely lost. At operation the affected nerve appears to be uninjured, and the type of injury is appreciated only by the fact that the opposite walls of the uninjured sheath have fallen together over a limited section. Although theoretically the downgrowth of fibres from the central to the distal segments is a possibility, it is found that this growth does not occur unless the empty portion of the sheath is exsected and the two prepared ends joined together, as for a complete nerve division.

Involvement of a Nerve in Scar Tissue. A nerve trunk may be involved in scar tissue, either in the centre of a mass, which compresses it and eventually interferes with its function, or by adhesion of the scar to one side of the trunk, usually producing a deviation of the nerve from its normal course. The latter type of involvement, although apparently not so serious, usually causes an earlier and more complete loss of function than the former. Even slight kinking of the nerve may lead to a

complete block in function, while conductivity is often present in spite of severe circular compression. If the interference with the nerve function is caused by involvement in the scar and not by destruction of nerve fibrils, relief can be obtained by dissecting the scar tissue from the nerve and preventing its re-formation by placing the freed nerve in a healthy intermuscular space. The decision as to the advisability of simple transplantation to a new bed, or exsection of the affected nerve segment, is arrived at in the same manner as that used when dealing with nerve fibromata.

Difficulties Encountered in Nerve Suturing

When a considerable portion of a nerve has been destroyed, it may be impossible to bring together the two prepared nerve ends whose junction is essential for a restoration of function. A considerable gap may be bridged by alteration of the position of a neighbouring joint; thus, by flexion of the elbow, a wide gap in the median nerve may be closed, or the two ends of a divided musculo-spiral nerve may be approximated without tension, but even with these alterations of position it is often impossible to bring the ends into apposition. Occasionally, when the central segment of the divided nerve is held in position by an important branch, approximation—which was previously impossible—becomes comparatively easy by separating the branch from the trunk for some distance by blunt dissection, or if the retaining branch is of little importance it may be sacrificed.

Although it is occasionally possible to transplant a nerve for a considerable distance to a new area, and by this means bring together the two divided ends, the wide dissection and freeing of the nerve from its blood supply diminishes the chance of recovery of function and increases the probability of fibrosis occurring in the transplanted nerve. The following methods, which have been used in the past to close a gap in a divided nerve, are of historical interest, but are not now considered to be of any practical value.

1. Turning a flap of nerve tissue from one or other segment of a divided nerve to bridge the gap.
2. Passing sutures from one nerve end to the other across a gap, which is then surrounded by fat flap, fascia or vein.

Nerve Transplantation. The operation of nerve transplantation was attempted on many occasions during the 1914–18 war, but the results obtained were so bad that the method was condemned as useless. Recently the work of Seddon (*British Journal of Surgery*, 1947) had indicated that the unsatisfactory results then obtained were probably due to faulty technique.

Using sections of mixed or sensory nerves from the same patient to

fill the gap in the injured nerve, it has been shown that recovery of all or part of the function of the divided nerve has been obtained in at least 50 per cent. Further work along these lines is indicated in order to clarify the possibilities of the method.

The approximation of the divided nerve-endings is sometimes possible by the use of the so-called two-stage suture. This method is of value in lesions of the great sciatic nerve when, after extensive destruction, it is found to be impossible to approximate the divided ends, even after full flexion of the knee-joint and hyperextension of the hip. With the limb in this position the two ends are brought together as nearly as possible by sutures, and the limb fixed in this position for 3–4 weeks, the knee being then slowly straightened and the hip flexed. When the knee is straight a second operation is undertaken, when it is usually found that the nerve-ends can now be brought together by full flexion of the knee. There are many theoretical objections to this method of forced stretching of a nerve with the object of bringing together widely separated ends. Recovery of function in the sutured nerve is never complete, but improvement has occurred on many occasions to a degree sufficient to prevent the necessity of subsequent amputation.

Difficulty of Finding a Suitable Bed for the Sutured Nerve. In most situations it is possible after suture to find a suitable unscarred intermuscular bed in which the nerve may be placed, but occasionally, on account of very severe soft tissue injury, or when the lesion has occurred in a position such as the flexor aspect of the wrist, there is no such space available. The use of pedunculated fat or muscle flaps as covering sheaths has not been satisfactory, the flaps, even when pedunculated, tending to become fibrotic and causing constriction on the nerve trunk, a tendency which is much greater when free flaps are used in this way. Although it is not always possible to provide an ideal bed for the injured nerve, use can be made of neighbouring tendons, even when the more satisfactory muscle bellies are not available.

After-treatment of Nerve Operations

During the period of anæsthesia and loss of motor power, the affected tissues must be protected and a good vascular supply maintained until *function has been restored. Gentle massage, combined with protection* of the paralysed muscle from the overstretching which follows on the unbalanced action of the opposing group of muscles, form the basis of treatment. The use of electrical stimulation of the muscles during the period of their recovery is of advantage only when employed with the greatest care. Over-stimulation of the affected muscles by the galvanic current can retard the recovery, while a few gentle contractions carried out each day improves the blood supply of the muscle mass.

Prognosis

The possibility of recovery of function following operation on an injured nerve depends on many factors, of which the most important are:

1. *Type of Nerve Involved.* Complete recovery of sensation and motor power is extremely rare after suture of a mixed nerve; the efferent or motor fibres show a greater restoration than the afferent or sensory fibres. Although the return of power in all the muscles supplied by the injured nerve is common, the return of sensation is always incomplete, the patient usually being able to appreciate touch and pressure but being unable to differentiate fine differences of temperature or to localize pin-point contact. As a result, the musculo-spiral nerve, which is composed largely of motor fibres, has a very favourable prognosis as compared with the median, in which the proportion of sensory fibres is much greater.

2. *Size of the Muscles Supplied.* The larger the size of the muscle which is paralysed the greater is its chance of recovery after suture of its motor nerve. Thus, the delicate lumbrical and interossei muscles frequently remain paralysed in spite of complete recovery in the large muscle masses on the flexor aspect of the limb.

3. *Time between Injury and Operation.* The most hopeful time for operation is immediately after the injury; the greater the interval, the less hopeful is the prognosis. The completeness of recovery following the operation rapidly decreases as the interval lengthens, and although no definite time limit can be stated debarring the patient from any prospect of improvement, it will usually be found that after an interval of 2 years even a perfect end-to-end nerve suture is followed only by an indefinite alteration in sensation and, in very rare instances, some slight improvement in muscle power.

4. *Sepsis.* The occurrence of sepsis in the neighbourhood of a nerve lesion, either following the original injury or at any subsequent operative procedure, is followed by fibrosis in the nerve and the surrounding tissues. Complete recovery of function in the injured nerve cannot then take place owing to the compression and destruction of many of the growing nerve fibres and to the loss of mobility of the surrounding tissues.

5. *Trophic Changes in the Tissues Supplied.* During the period of functional inactivity of the injured nerve, ulceration may occur in the area of anæsthesia, and, unless protected, this soft tissue destruction may extend into the underlying tissues and may even involve a neighbouring joint or one of the underlying bones. If such destruction has occurred, full function of the limb is never obtained, even in the presence of a good restoration of the motor and sensory loss.

6. *End-to-End Suture.* Unless this has been possible at the time of operation, the prospects of any recovery are nil.

7. *Site of Injury to the Nerve.* If the injury and the subsequent

suture of the divided nerve have taken place at the origin of several of its branches, the chances of recovery are greatly diminished. When the nerve has been injured and sutured in its course at some distance from the point of origin of any branches, the resulting scar is minimal and is confined largely to the sheath; but if several branches have to be sutured to a main trunk, the greatly increased amount of scar tissue caused by the multiple suture lines prevents the normal down-growth of the nerve filaments, and forms a massive intraneural fibroma.

8. *Extent of Separation of the Injured Nerve from its Bed.* If suture has only been possible by a very extensive separation of the injured nerve from its surrounding tissues, the chances of recovery of function are gravely affected by the intraneural fibrosis which results from cutting off much of its normal blood supply.

INJURY TO SPECIAL NERVES

Musculo-spiral Nerve

Owing to its close apposition to the humerus through its whole course, the musculo-spiral nerve is peculiarly liable to injury. These injuries may be partial, as instanced by the crutch paralysis, or "Saturday night palsy," which is caused by pressure in the axilla, or complete, as when the nerve is involved in a compound wound or in a fracture of the humerus, either immediately by tearing at the time of fracture, or later by involvement in scar tissue or callus when consolidation is occurring.

Signs of Loss of Function in the Musculo-spiral Nerve

When the loss of conductivity in the nerve is complete the effects vary with the site of injury. As a rule, the triceps muscle retains its power of contracture, as the motor branches to its upper head arise at a high level above the usual point of injury to the nerve trunk. All the muscles which extend the wrist, fingers and thumb are paralysed and wasted, as are also the anconeus supinator and brachio-radialis. As a result the hand falls into a position of drop wrist, and if this position is not corrected a secondary contraction of the flexor muscles and capsule of the wrist will prevent even passive dorsiflexion. The area of complete anæsthesia is small, being confined to a small patch of skin over the dorsum, between the 1st and 2nd metacarpals and the adjacent bases of the thumb and index finger.

Differential Diagnosis

The two conditions from which musculo-spiral paralysis must be differentiated are:

1. *Lead Paralysis*, which is always bilateral and is accompanied by other general signs of absorption, of which the most common is gingivitis.

2. *Hysteria*, which is not accompanied by muscular wasting, or by loss of sensation limited to the area described.

Treatment

Drop wrist, the result of axillary pressure, responds readily to physiotherapeutic measures. If the injury has been caused by the use of a crutch, this must be discontinued until the muscles have recovered. The hand and fingers should at once be placed in a position which provides relaxation for the paralysed extensor muscles, and this position must be retained until function is restored. The long hand splint (Fig. 12), which maintains the wrist at 30 degrees dorsiflexion with the metacarpophalangeal and interphalangeal joints in slight flexion, is entirely adequate. The position of flexion at each of the joints of the fingers is essential if the rigidity which follows on prolonged fixation of these joints in extension is to be avoided.

During the period of muscular relaxation the circulation of the affected muscles must be maintained by massage combined with a minimal amount of electrical stimulation by the galvanic current. When the clinical examination and electrical reactions of the affected muscles indicate that the nerve has been divided, operation must be carried out on the lines already indicated.

Operation. When the nerve lesion is present in the lower part of the arm, operation usually presents little difficulty. The nerve is defined above and below the site of injury and the necessary freeing carried out before end-to-end suture is undertaken. If a wide gap is present between the divided ends, approximation is usually possible by full flexion of the elbow before suturing. Complete transposition of the divided nerve in front of the humerus leads to still further approximation, but the operation is inadvisable on account of the unavoidable loss of blood supply, which promotes fibrosis in the sutured nerve and prevents full restoration of function.

When the lesion has occurred in the middle of the fibrous tunnel in which the nerve lies on the back of the humerus, there may be considerable difficulty in defining its boundaries and dissecting out the divided ends. It is usually impossible to do this from either the upper or lower approach alone. The nerve should first be identified on the outer and lower aspect of the arm between the triceps and brachialis anticus. From this spot it is followed upwards until the site of injury is found. Through another incision in the axilla the upper part of the nerve is identified before it enters the fibrous tunnel; this end is then followed downwards and its termination cleared. Enough space to perform a suture can usually be obtained through one or other incision, and after the suture has been completed a thin pedunculated layer of

muscular tissue from the triceps is placed between the site of suture and the bony lesion.

If end-to-end suture of the nerve is not possible the function of the hand and forearm may be restored to a very large extent by means of tendon transplantation. In this operation active muscles on the flexor aspect of the forearm, whose loss does not destroy the function of the hand, are used to replace the action of the paralysed extensor group.

Operation of Tendon Transplantation far Musculo-Spiral Paralysis. A vertical incision, $2\frac{1}{2}$ inches long, is made over the outer aspect of the middle of the shaft of the radius at the level of the insertion of the pronator radii teres. Overlying the insertion is the tendon of the supinator longus, which is pulled forward. The pronator radii teres tendon is then completely detached from the radius and is transplanted through a vertical cut made in the centre of the adjacent tendons of the extensor carpi radialis longior and brevior, the wrist being maintained in dorsiflexion during the whole course of the operation. Vertical incisions are then made along the course of the flexor carpi radialis and ulnaris tendons, which are divided at their insertions and freed for at least 4–5 inches up the forearm. An oblique incision is then made over the back of the wrist, and after freeing widely the subcutaneous tissues between the incisions, the flexor carpi radialis and ulnaris tendons are transposed subcutaneously round the borders of the radius and ulna respectively. The flexor carpi ulnaris is then passed through slits in all the extensor tendons of the fingers, and the flexor carpi radialis similarly through the three extensor tendons of the thumb, care being taken that the fingers and wrist are kept in dorsiflexion during the whole procedure. The subcutaneous tissue and skin are then sutured, and the hand and fingers are maintained at the same angle in which the wrist is dorsiflexed about 10–15 degrees for a period of 3–4 weeks when voluntary movements of the wrist, hand and fingers should be encouraged.

The success of the operation depends largely on muscle re-education, the patient must be taught to use the wrist flexors as extensors of the fingers, and must be encouraged to practise all the movements which are normally employed in his occupation. The results of this form of treatment are usually so good that the patient can return to any form of work.

Posterior Interosseus Nerve

Injuries to this nerve trunk are usually caused by penetrating wounds or fracture of the neck of the radius, and loss of function in the nerve is indicated by the presence of a complete paralysis of the extensor muscles of the fingers, whilst the power of dorsiflexion of the wrist remains, owing to the continued activity of the extensor carpi radialis

longior, which is innervated by the musculo-spiral nerve before its division (Fig. 131).

The chances of recovery of function following suture of a divided posterior interosseous nerve are extremely poor, even though the fibres in the nerve are almost entirely motor. The cause of the failure is to be found in the proximity of the terminal branching of the short posterior interosseous trunk necessitating suture of the many separate divisions to the single trunk.

Occasionally, in clean-cut wounds close to its origin successful suture of the divided nerve is possible. Recovery of function can be obtained even in the presence of permanent paralysis by tendon transplantation, as already described in the treatment of paralysis of the musculo-spiral nerve. As the carpi radialis longior muscle remains active it is not necessary to transplant the pronator radii teres tendon.

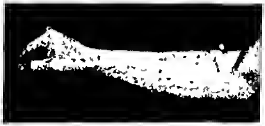


FIG. 131 —Paralysis of Posterior Interosseous Nerve, showing action of extensor carpi radialis longior with paralysis of extensors of fingers.

Ulnar Nerve

Injury to this nerve may be produced by:

1. Fracture in the region of the elbow-joint.
2. Penetrating wounds of the arm or forearm.
3. Constantly repeated dislocations of the nerve from its groove behind the internal epicondyle.
4. A condition known as late ulnar neuritis, which follows on a cubitus valgus or cubitus varus deformity of the elbow.

The signs of this last condition rarely appear before adult life, although the cause of the deformity at the elbow is almost invariably a loss of growth of the outer or inner aspect of the lower end of the humerus following a fracture of one of the condyles occurring in early childhood (Fig. 132).

Signs

When a complete lesion of the nerve has occurred at or above the elbow-joint, it is indicated by the following signs:

1. Paralysis of the flexor carpi ulnaris muscle with diminished power of action of the flexor profundis on the little nnd ring fingers.

2. Paralysis and wasting of all the muscles of the hypothenar eminence and of the two inner lumbricals, the interossei, the adductors of the thumb and the deep head of origin of the flexor brevis pollicis.

FIG. 132.—Ulnar Palsy, showing deformity of middle and ring fingers and wasting of interossei.

3. Anæsthesia over tho little finger, half the ring finger and the hypothenar eminence, the anæsthesia extending upwards to the level of the pisiform bone (Fig. 133).

When the injury has occurred in the forearm the long flexor muscles are not affected, but in all cases of complete division of the nerve the power of adduction of the extended little finger to the ring finger is lost. This movement of adduction of the little finger is the most valuable single test of the activity of the ulnar nerve, but is of no value unless performed with the fingers in full extension.

Treatment

Lesions of the nerve occurring in the arm or forearm are treated as already described by freeing or by end-to-end suture and rebedding in a healthy intermuscular space. When the injury is present at the elbow-joint it is often impossible to find a smooth covering for the line of suture, and in addition it is also essential in many cases to remove the nerve from the repeated irritation of the condyle of the humerus, or to shorten its course in order to obtain end-to-end apposition. These points are

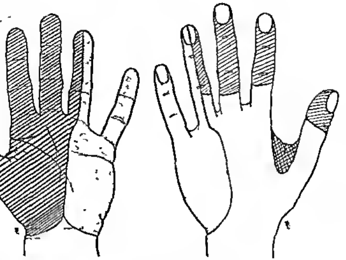


FIG. 133.—*Showing cutaneous area supplied by*:
(*a*) Median Nerve (single shading)
(*b*) Ulnar Nerve (stippling)
(*c*) *Musculo-spiral Nerve (double shading)*

met by transplantation of the nerve in front of the humeral condyle, where it can be placed in an unaffected intermuscular space

Transposition of the Ulnar Nerve. The trunk of the nerve is *freely exposed above and below the elbow-joint* and raised from its bed on the posterior aspect of the internal condyle of the humerus. The internal intermuscular septum is now divided, together with the articular branch passing to the elbow-joint, and the muscular branch to the flexor carpi ulnaris is, if necessary, freed by blunt dissection for some distance upwards. A new bed is then made for the nerve in the substance of the muscle bellies in front of the internal condyle by division of the aponeurosis and superficial portions of the underlying flexor muscles, which are then sutured loosely over the implanted nerve. The nerve must lie loosely in this new bed and must not be angled or kinked in its new course.

In the after-treatment of any operation on the ulnar nerve, whether by *suture or transplantation*, the hand and fingers should be massaged, but the use of a splint of any type should be avoided because of the danger of the development of rigidity in the metacarpophalangeal and interphalangeal joints.

Median Nerve

Most of the injuries to this nerve occur as complications of perforating wounds in the region of the wrist-joint, the nerve injury often being

associated with division of the flexor tendons of the hand and wrist. Occasionally the nerve is involved in fractures about the elbow-joint or the forearm, those in the region of the joint being caused by the displacement forward of the lower end of the upper fragment of the humerus, by which the nerve is bruised or divided.

Signs

The clinical signs are very obvious:

1. Anæsthesia over the thumb, index, middle and half the ring fingers on the anterior aspect, and over the terminal two phalanges of these fingers and the terminal phalanx of the thumb posteriorly.
2. Paralysis and wasting of the muscles of the thenar eminence.
3. Wasting of the pulp of the index and middle fingers.
4. When the lesion occurs at or above the elbow-joint, all the muscles

Fig. 134.—Median Palsy, showing wasting of thenar eminence and inability to flex thumb and index finger.

of the flexor aspect of the forearm, except the flexor carpi ulnaris and the neighbouring portion of the flexor profundis muscle, are also affected (Fig. 134).

Treatment

When it is obvious that the nerve has been divided, end-to-end suture should be undertaken without delay, even when a considerable gap is present. It is possible to bring together the divided ends by flexion of the elbow and possibly also by flexion of the wrist-joint, although every effort must be made to avoid prolonged fixation of the wrist in flexion on account of the fixed deformity which may follow on immobilization of the joint at this angle. The chief difficulty encountered in the operation is the provision of a suitable smooth scar-free bed in which the sutured nerve may lie and be protected from pressure and from subsequent fibrosis. At the wrist there are no muscle bellies available for this purpose, and attempts have been made to provide a suitable covering by using a

pedunculated or free fat or fascial flap to cover the line of suture. These flaps unfortunately become themselves fibrotic and cause increased pressure on the nerve trunk, leaving only the tendons of the flexor muscles to act as a sheath.

Prognosis

After a successful suture of the median nerve, sensation, though never completely restored, is improved, while some power returns in the muscles of the thenar eminence. When sutured above the elbow-joint, recovery in the flexor muscles of the forearm averages about 60 per cent of the normal power.

Brachial Plexus

Although the plexus is occasionally injured by a direct penetrating wound, its injuries are more frequently indirect, through traction on the arm or through the pressure of growths or abnormal bone formations in its neighbourhood. The most common story of injury is that of a fall on the tip of the shoulder, the head being forced towards the other shoulder, the tear lesion of the plexus so produced being often accompanied by a fracture of the clavicle or a dislocation of the shoulder. Occasionally the site of the injury to the cords of the plexus is found at a lower level when the dislocated head of the humerus is pushed forward into the axillary space. Injuries of the nerves forming the plexus do not always occur at the same level, and may involve all or any part of its structure. Occasionally the lesion is confined solely to the anterior nerve roots, producing paralysis without loss of sensation, but, as a rule, the posterior roots are also involved, with a corresponding anæsthesia over the area of distribution.

Signs

The clinical signs produced by the injury naturally depend on the site of the lesion, and by a careful examination this point can usually be mapped out accurately. Thus, the 5th and 6th cervical nerves supply the shoulder girdle group of muscles, i.e., deltoid, spinati, teres minor, brachialis anticus, biceps and supinator longus. Paralysis of these muscles, described as the Erb Duchenne syndrome, indicates a lesion of the 5th and 6th cervical nerves, but does not indicate its exact site. This point can be more accurately defined by examining the condition of the serratus magnus and rhomboid muscles, which are also supplied by branches from these nerves close to the intervertebral foramina. If these two muscles are also paralysed the injury must lie internal to the point of origin of their nerve supply, suggesting a root lesion, for which no operative treatment is of benefit. If, however, these two muscles retain their activity, it is evident that the injury lies external to the point of origin of their nerve supply, and operation is indicated if

improvement in the paralysed muscles is not observed after three months' treatment by physiotherapy.

Lesions of the posterior roots of these two cervical nerves produce anæsthesia over the outer aspect of the arm and forearm, the severity of the injury to the posterior roots being judged by the extent of the anæsthesia. Complete plexus injuries, in which all the five nerves forming the plexus are torn from the cord, are commonly caused by a fall on to the point of the shoulder. The accompanying paralysis of the muscles of the hand, forearm and arm is complete, and with this the action of the rhomboids and serratus magnus muscles is also lost. Anæsthesia is present over the whole limb, with the exception of a small area on the front of the shoulder and inner side of the arm which is supplied by descending cutaneous branches from the 3rd and 4th cervical nerves.

Injury to the lower part of the plexus is commonly caused by traction on the arm above the head; in this position the lower cords of the plexus are strained or torn, both types of lesion usually occurring close to the origin of the nerves from the cord.

The syndrome produced by rupture of the 1st dorsal and 8th cervical nerves, which is known as the Klumpke or lower arm type of plexus lesion, is characterized by paralysis and wasting of all the intrinsic muscles of the hand with paresis of the common flexor muscles. When the injury is present close to the canal, the sympathetic fibres which run in the 1st dorsal trunk are also involved, leading to a contraction of the pupil, drooping of the eyelid and dryness of the skin of the face on the same side.

With root lesions there may or may not be cord involvement according to the site of injury. Thus, if the lesion is intrathecal, root signs, such as slight increase of the extensor type of response (Babinski), may be present, but occasionally these signs of cord involvement may come on later, due to the formation of adhesions. If, however, the injury has occurred extrathecally, no such alteration in the nerve reactions is to be expected.

Treatment

The decision as to the treatment which should be adopted rests solely on the localization of the site of injury. If a root lesion is present there is no justification for any form of operative interference, but if the signs indicate that the nerve trunks are torn distal to the origin of the nerve to the rhomboids, operation is indicated, especially in lesions of the upper segment of the plexus.

Operation. Through an incision 6 inches in length, parallel with the posterior border of the sterno-mastoid muscle, the posterior triangle is expanded by retraction of the muscle anteriorly. The transverse

cervical artery and vein, which traverse the middle of the space, are identified and ligatured, after which the upper trunks of the plexus can be inspected by retracting the scalenus anticus muscle. Freeing of the nerves from adherent scar tissue or even end-to-end suture is usually practicable, although always a difficult problem. If more room is necessary in the operation field, it may be obtained by continuing the incision backwards along the line of the clavicle from its lower border for 3 or 4 inches.

When the injury has involved the 8th cervical and 1st dorsal nerves alone, suture of the divided ends is so difficult as to render the operation inadvisable. Treatment must, under these circumstances, be confined to improvement in the tone and size of the affected muscles by physiotherapy in the hope that the division is not complete and that regeneration of at least a part of the affected plexus may occur.

Great Sciatic Nerve

Although the great sciatic nerve may be injured by severe strains, producing intrathecal rupture of its constituent nerves, its injuries most commonly occur as complications of penetrating injuries or in association with fractures or dislocation of the hip-joint. A complete division of the nerve is followed by anæsthesia of the whole of the limb below the knee, except for a strip of skin on the inner aspect in front and behind the tibia. The foot is completely flail and usually remains in a position of equinus; the limb is cold with a pale dry skin, which is readily injured unless protected from irritation. If a sore is allowed to develop in the anæsthetic skin of the foot it may spread over a wide area, but more frequently it extends deeply into the sole of the foot, the so-called perforating ulcer with its unhealthy granulating edges. The ulceration may involve the soft tissues only, or may extend down to produce osteomyelitis of one or more of the metatarsal bones, a complication which may eventually necessitate amputation of the limb. The anterior tibial nerve may be injured alone, either in the thigh through a penetrating wound, or in the region of the neck of the fibula by direct violence or as a complication of a fracture in this region. The injury is followed by paralysis of all the extensor muscles of the leg and foot, and by the appearance of an area of complete anæsthesia of the skin over the dorsum of the foot at the base of the 1st and 2nd toes (Figs. 135a and 135b).

Treatment

Suture or freeing of the injured sciatic nerve is carried out through an incision over its course. On account of its size the nerve is found easily, and, as a rule, if completely divided, the ends are brought together without difficulty when the hip is extended and the knee flexed. In

the case of a large gap which cannot be closed by this manœuvre, the two-stage suturing—already described—is employed with advantage.

Difficulty is often experienced in approaching an injury to the great sciatic nerve close to its point of emergence from the pelvis. Two methods of approach may be adopted; the first by splitting the fibres of the gluteus maximus muscle, permitting a view of the nerve close to the pelvis but preventing a full inspection of its course downwards. The second and more efficient approach is gained by a temporary detachment of the tendon of insertion of the gluteus maximus muscle from the femur. After completing the operation on the nerve the tendon can be reattached without fear of any subsequent loss of power.

(a) (b)

FIG. 135.—(a) Cutaneous area of Foot and Leg supplied by internal popliteal.

FIG. 135.—(b) Cutaneous area of Foot and Leg supplied by external popliteal.

When the nerve has been identified in the thigh it may be evident that the injury involves only one portion of the trunk, while the other segment remains uninjured. These two portions, internal and external popliteal, emerge separately from the pelvis and develop a common sheath but never form a single nerve mass. For this reason it is often possible to separate the injured from the uninjured portion of the nerve—a procedure which is not possible in injury to any other nerve.

In the case of injury to the external popliteal at the level of the neck of the fibula, the only difficulty consists in the provision of a new bed free from the risks of subsequent adhesions. This can usually be provided by the use of a pedunculated muscle flap turned up from the outer head of the gastrocnemius.

If it is evident that restoration of the function of the sciatic nerve is impossible the question of amputation of the limb is frequently raised. Even complete and permanent loss of the sciatic nerve does not necessitate amputation of the limb unless other severe deformities or septic infections are present. Many of the men who sustained such injuries in the 1914–18 war are still working and using the limb freely with support, as a result of the persistent care and attention paid to the foot. The skin must be washed carefully every day, dried, and rubbed with methylated spirit, special care being taken of the shoes and socks, and if these points are carefully watched ulcers and other complications can be avoided.

Prognosis

The prognosis for recovery of function after suture of the great sciatic nerve is, on the whole, bad. This is especially true in regard to the internal popliteal nerve, whilst recovery after suture of the external popliteal division does not, as a rule, exceed 60 per cent of the normal function.

The general impression of hopelessness in regard to the return of function after suture of this nerve is largely the result of war surgery, where such injuries are always complicated by severe tearing of the surrounding tissues and an almost inevitable superadded infection. Both of these factors tend to prevent a restoration of function, but, in the case of a simple cut of the sciatic nerve free from infection, the prognosis need not be looked on as unfavourable.

CHAPTER XX

AFFECTIONS OF MUSCLES AND TENDONS

TENDON RUPTURE

Any tendon may be strained or torn as a result of excessive tension, but, as a rule, these injuries occur only at certain areas in which the tendons are subjected to abnormal stress, especially where they lie and act in a bony groove. The most common tendon and muscle tendon injuries are so constant in their occurrence that they can be described under the following headings.

TENNIS ELBOW

Pain and tenderness in the region of the radio-humeral joint is often caused by prolonged and vigorous use of the extensor muscles of the hand and forearm at any occupation, or from any kind of exercise, but this disability is so frequently found in tennis players that it has been given the title of "tennis elbow." The pain and tenderness are not always situated in exactly the same area, but are usually complained of over the back of the external epicondyle of the humerus, the posterior aspect of the radio-humeral joint, or in the region of the head or neck of the radius. Although the tenderness is present over the extensor muscles, it would appear that only the extensors of the wrist-joint are involved in the strain. Thus, when the wrist is fixed the fingers can be extended against pressure without causing pain, whilst dorsiflexion of the wrist against pressure causes immediate discomfort. No bony abnormality can be demonstrated, and passive movements are painless through almost the whole of the normal range.

Theories as to Cause

1. *Strain of the Extensor Muscle Tendon Junction.* This obvious explanation would seem to account for the disability in the majority of cases. As a result of excessive use a tear has occurred in the extensor muscles and in the muscle tendon junction. Hæmorrhage at the site of strain has been followed by the formation of adhesions which, when pulled on, cause pain locally and down the course of the affected muscles.

2. *Bursal Development under the Common Extensor Tendon of Origin.* This explanation of the cause of the disability has been advanced by Osgood, who states that its presence was proved in his own case where

removal of the bursa was followed by complete relief. Most surgeons have been unable to find this bursa in "tennis elbow," even after the most careful dissection.

3. *Reduplication of the Synovial Membrane of the Radio-Humeral Joint and Subluxation of the Head of the Radius* have also been suggested as possible explanations of the cause of the disability, and it is probable from the variations in the site of tenderness that no single explanation can be advanced to cover all possible causes.

Treatment

When the disability is comparatively slight some relief can be obtained by the use of a band of strapping applied tightly round the forearm, just below the site of tenderness. With this support the patient can usually carry on and use the muscles freely, and with comparatively little discomfort.

Relief can also be obtained by immobilizing the wrist in slight dorsiflexion. In this position the fingers can be used freely, and with prolonged fixation permanent relief may occasionally be obtained. Unfortunately this period of fixation must extend over many months, and permanent relief does not always follow its use. Deep massage of the tender area, employed either alone or combined with rest of the wrist on a splint, leads to a diminution of the tenderness and occasionally to a disappearance of all symptoms.

Manipulation. If the disability is of long standing, and the simple measures already mentioned have failed to improve the condition, manipulation offers the best prospects of cure. The object of the manipulation is to break down the adhesions which have formed in the area of strain in the common extensor origin, or in the region of the head of the radius. The manipulation should always be carried out under anæsthesia; without complete muscular relaxation the resistance of the patient prevents complete correction.

The manipulation is completed in stages; the wrist is first fully palmar flexed with the forearm in extreme pronation (Fig. 136). In this position the patient, if not under anæsthesia, holds the elbow bent to relieve the strain. Whilst the wrist and hand are held in this position, the elbow is forced into full extension, this movement usually being accompanied by a definite sensation of a click or tear. The elbow is then moved laterally with the joint slightly flexed, in order to complete the manipulation.

After-treatment consists in free use of the hand, carrying out especially those movements which previously caused the pain, massage being given during the first few days with the object of relieving tenderness and increasing power.

Fig. 136.—Manipulation for Tennis Elbow

Operation. If manipulation fails and pain and tenderness remain, cure is almost certain following open operation. Through a short incision over the external condyle of the humerus, the common extensor muscular origin is raised from its bony attachment by a sharp elevator No sutures are used for reattachment of the muscle, and after removal of the skin stitches the patient is advised to use the hand and arm normally.

RUPTURE OF THE COMMON EXTENSOR TENDON OF A FINGER

This is probably the most common example of tendon rupture, and results from forced flexion of the terminal joint whilst the extensor tendon is voluntarily contracted. The injury is usually sustained while the housewife is smoothing the sheet on a bed, or when the cricketer or footballer catches a ball on the tip of the finger. After the injury the terminal joint of the finger remains in acute flexion. Voluntary power of extension is lost, little or no swelling is present, and the radiograph may, or may not, show a small bony flake torn from the dorsum of the base of the terminal phalanx.

Treatment

In the absence of a bony injury open suture of the divided tendon has been found to be unsatisfactory; the frayed tendon cannot be sutured to the periosteum or bone, and failure is to be expected.

As a rule, the function of the finger can be restored by fixation of the joint in slight hyperextension for a period of 4–8 weeks until the ruptured tendon has reunited. The fixation should be confined to the terminal joint, free movement being allowed at the metacarpophalangeal and proximal joints. The possibility of recovery by this means depends largely on the length of time which has elapsed between the injury and the commencement of treatment. If started immediately after the accident a restoration of function is to be expected, but the chances of recovery are reduced with each day's delay.

RUPTURE OF THE EXTENSOR LONGUS POLLICIS TENDON

This long delicate tendon, which passes in a bony groove obliquely across the back of the lower end of the radius, is frequently torn as a complication of fracture in the neighbourhood of the wrist-joint, or rupture may occur in the absence of any severe injury in patients over 40 years of age, in whom extensive osteoarthritic changes are present. The roughening of the cartilage-lined bony groove in the radius is sufficient to cause a gradual fraying, and finally a complete rupture of this delicate tendon.

Signs

Inability to extend the terminal phalanx of the thumb, combined with some tenderness on pressure over the site of injury in the bony groove on the radius.

Treatment

Restoration of function is only possible by open operation.

Operation. Through a 3-inch incision over the course of the tendon, the two ends are identified, and if possible are brought together and sutured with catgut. If easy approximation is impossible, or if the widespread fraying of the tendon renders a successful suture improbable, the proximal end of the distal segment should be *implanted into the* tendon of the extensor carpi radialis longior or brevior, which lie just below the site of injury. Fixation of the thumb following the operation permits union of the tendon, and full activity can then be restored by active use.

TRIGGER FINGER

The disability to which this description has been given may affect any of the fingers or the thumb. The patient states that when bending the finger it becomes stuck in a position of semi-flexion, and then on further effort the movement is completed suddenly with a jerk. When fully flexed there may be equal difficulty in straightening the finger, and occasionally locking may continue for days, or even weeks, in spite of the patient's most strenuous efforts.

Causes

The condition is usually the result of trauma, but occasionally in children a similar disability is present as a definite congenital deformity. Mechanically the action of the flexor tendon may be interfered with by enlargement of the tendon itself, or by contraction of its fibrous sheath, either of which may be produced by severe localized trauma.

Signs

With palpation of the palmar aspect of the affected finger a hard lump can be felt moving in the region of the metacarpophalangeal joint; as flexion is completed this lump can be felt to jump suddenly from the base of the phalanx into the palmar region.

Treatment

No form of physiotherapy can have any effect on the enlarged tendon. The area of obstruction should be approached through an anterior incision, and the tendon sheath divided for a distance of 1 inch, the sheath being left open without suturing. The removal of part of the centre of the enlarged tendon through a lateral incision, leaving the sheath in its original condition, is a much less reliable procedure, as a re-formation of the enlargement usually follows.

RUPTURE OF THE TENDO ACHILLIS

This injury rarely occurs in patients under 40 years of age, and is seen most commonly in men who have been athletic with well-developed muscles, which have degenerated somewhat through want of use. The rupture usually involves the narrowest part of the tendon about 1½ inches above its insertion into the os calcis, and although usually complete it is never clear-cut, the two ends being ragged to an extreme degree. The upper end retracts, leaving a gap filled with blood clot within an unbroken tendon sheath. The plantaris tendon, although delicate in comparison with the tendo achillis, has never been found at operation to be involved in the rupture.

Symptoms and Signs

These are quite definite—a sudden acute pain in the lower part of the calf, followed by a temporary feeling of uselessness of the leg. The pain gradually disappears and the patient can walk, but the power of standing on tiptoe is lost and a definite gap can be felt in the continuity of the tendo achillis.

Treatment

Palliative treatment consists in raising the heel of the shoe, thereby relieving the strain on the calf muscles and the divided tendon. By *this means walking is improved, but the continuity of the divided tendon* can be restored only by open operation and suture of its separated fragments.

Operation. With the knee bent to an angle of 90 degrees, a 5-inch vertical incision is made through the skin on the outer aspect of the tendo achillis; the skin is reflected and the sheath opened. The upper and lower portions of the tendon are then identified and brought as closely together as possible, the foot being kept at right angles during the whole operation. If the rupture has occurred recently it may be possible to suture the ends together firmly with kangaroo tendon, or with chromic gut, but if complete, approximation cannot be secured; two lateral tendinous flaps from the upper segment should be turned down and sutured through the lower segment. The operation is completed by suture of the sheath and skin, after which the foot is fixed at right angles in a plaster-of-Paris case for 6-8 weeks. Walking may then be permitted and voluntary exercises encouraged with every prospect of complete restoration of function.

RUPTURE OF THE PLANTARIS MUSCLE

Rupture of the plantaris muscle has for long been considered as the explanation of the sudden acute pain in the calf of the leg, which occasionally occurs during active exercise. The diagnosis has been made from the localization of pain, and because of the comparative weakness of this muscle. It is probable, however, that the plantaris muscle is never torn under such circumstances, and that the injury consists in a tearing of muscular fibres at the junction of the two heads of the gastrocnemius muscle.

Signs and Symptoms

Tenderness on pressure over the middle of the calf, and pain on passive dorsiflexion of the foot, or on attempting to stand on tiptoe.

Treatment

Recumbency is not necessary in the treatment of this injury, and the patient may be allowed to carry on his ordinary duties. Relief of tension on the torn muscle fibres is obtained by raising the heel of the shoe at least three-quarters of an inch; this increase of the height of the heel is continued for 3–4 weeks, after which it is slowly reduced to normal. Improvement in the local condition can also be obtained by deep massage of the tender area, and by placing a firm pad, held by circular strapping, over the site of tenderness. The pain and disability usually disappear in 6–8 weeks, but recurrence of the injury is comparatively common.

RUPTURE OF THE LIGAMENTUM PATELLÆ

This comparatively rare injury may be sustained by an elderly patient undertaking severe and unaccustomed exercise, but occurs more often as a result of forced flexion of the knee under anæsthesia when a manipulation of the joint has been undertaken with the object of breaking down adhesions. The accident is likely to occur if the patella is wholly or partly adherent to the femur. If the adhesions are sufficiently firm the attempt at increasing movement may result in rupture of the ligament, the injury occurring close to its attachment to the lower border of the patella.

Signs and Symptoms

As a result of the rupture the power of active extension of the joint is lost, the patella, if movable, lies considerably higher than normal and a definite gap can be felt between the head of the tibia and the patella.

Treatment

Suture of the divided ligament should be carried out as soon as possible. If the operation is performed directly after the injury, overlap of the tendon and suturing with kangaroo tendon or chromic gut produces an excellent result. If a considerable interval has elapsed before the operation is undertaken, approximation may only be possible when the quadriceps tendon has been lengthened and the patella has been pulled down to a lower level. To secure this lengthening, the central tendinous portion of the quadriceps is defined and partially separated from the vastus internus and externus muscles. The tendon is now cut through half its substance on either side, the interval between the cuts being 3 inches. Stretching, or more preferably vertical division of the central portion, will then permit the elongation that is desired. Without elonga-

tion of the quadriceps the gap in the patellar tendon may be closed by a large flap of fascia lata taken from the same thigh, but this method has the disadvantage that in time, as a result of continued use, the transplanted fascia tends to stretch, leading to a recurrence of weakness and loss of extension of the joint.

After-Treatment. The patient is allowed to walk about after 3 weeks, the knee being immobilized to prevent strain on the sutured tendon. *Active movements of the joint without body-weight*, accompanied by massage of the thigh muscles, lead to a rapid return of the full range of movement.

RUPTURE OF THE QUADRICEPS FEMORIS

As a result of excessive voluntary effort, or through forced passive movement of a rigid knee-joint, the quadriceps femoris tendon may be torn close to its insertion into the upper border of the patella. *Occasionally a thin flake of bone is torn off with the tendon, the clinical* signs in either case being almost identical. The power of voluntary extension of the knee is lost, while a distinct gap can be felt above the patella.

Treatment

Conservative. The continuity of the tendon can be restored by fixation of the knee in extension for a period of 8–12 weeks. The gap between the tendon and its site of insertion becomes filled with strong fibrous tissue, through which the power of voluntary extension of the leg is restored.

Operative. *If the injury is comparatively recent*, suture of the torn tendon, or of the displaced fragment of patella, to its normal situation, lessens the period of incapacity, and rapidly restores function to the joint. After the operation the tendon is protected by rest in the extended position for 4 weeks, when active use and movements are allowed. The range of flexion may be limited for some weeks, but full movements are restored by exercise and physiotherapy.

RUPTURE OF THE RECTUS FEMORIS

This common injury results most frequently from a miskick at football. The rectus femoris muscle belly is pulled from its lower tendinous attachment and retracts upwards towards the hip. On active contraction the muscle appears as a large hard swelling, slightly above

the middle of the thigh, with a depression in the middle line between it and the upper border of the patella (Fig. 137).

Fig. 137.—Photograph showing rupture of Rectus Femoris.

Treatment

The final functional result is altered very slightly by any form of treatment. Exercises and massage of the injured quadriceps rapidly restores functional activity, and although the abnormal muscle mass remains visible full strength returns quickly. Occasionally, it may be considered advisable to attempt to restore the normal appearance by operation.

Operation. If the condition is discovered soon after the accident the muscle may, with considerable difficulty, be sewn to its tendon of insertion. If the operation is successful and the suture line remains firm, the appearance of the limb is improved, but the function following the operation is very little better than that following conservative treatment.

RUPTURE OF THE TENDON OF THE LONG HEAD OF THE BICEPS

This and *Rupture of the Supraspinatus Tendon* have already been dealt with in Chapter V among the Injuries to the Shoulder-joint.

TENO-SYNOVITIS

Inflammation of the synovial membrane lining a tendon and its sheath is of common occurrence following persistent over-use. The condition may be diagnosed by the local swelling along the line of the tendon sheath, by pain on active use, while in the more chronic type fine crepitus over the course of the tendon can be appreciated by palpation.

Sites

Although any tendon which is surrounded by a sheath may be affected in this way, there are certain tendons which are peculiarly liable to injury from over use. This is particularly so in the long extensor tendons of the thumb which work in bony tunnels. Normally these delicate tendons are subject to considerable strain; this is very greatly increased in those individuals whose work involves constantly repeated movements of flexion and extension of the thumb, such as bricklayers, machine-tool workers or packers, and in them the condition is found with comparative frequency.

Treatment

In the acute stage rest on a suitably designed splint is usually sufficient to cure the condition in 3-4 weeks, but in the more chronic type, where long-continued inflammatory changes have resulted in thickening of the synovial lining, the period of treatment may be considerably lengthened.

Cohen and Reid have shown that, in some instances, resistant and recurrent teno-synovitis is associated with the presence of oxaluria, and that successful treatment of this condition must precede the disappearance of the signs of teno-synovitis.

CHRONIC INFECTIVE TENO-SYNOVITIS

This condition is seen in its most obvious form in connection with the flexor tendons in the region of the wrist-joint, where it is known as compound palmar ganglion. Here, the common synovial sheath is affected by thickening and swelling, which becomes apparent as connected collections above and below the annular ligament. The sheath is infiltrated with fibrous tissue, its smooth shiny surface being lost by the development of areas of ulceration. Multiple small rounded melon-seed bodies are present in its cavity, and voluntary movements of the fingers are accompanied by creaking and grating, which can be detected on palpation.

The cause of the infection in at least 90 per cent is the tubercle bacillus, although it is often impossible to demonstrate the organism except on guinea-pig inoculation. The disease may remain in a chronic stage for many months, but, if untreated, the infection usually spreads to involve the underlying bones, or to break through the skin to form persistent sinuses.

Treatment

Prolonged immobilization of the wrist, hand and fingers should always be employed as soon as the diagnosis has been made. Resolution of the

swelling often results, and in some instances the normal function is restored without any further treatment.

If swelling persists, or increases in spite of immobilization, an attempt should be made to remove as much as possible of the infected tissue. Theoretically it is necessary to remove every portion of the synovia from the sheath and from the surface of the tendons themselves. This can be done through a vertical incision in which the annular ligament is divided and the lining removed. The functional result of this operation is usually bad, the tendons becoming involved in a dense mass of scar tissue.

Very considerable improvement, and in many cases cure, can be obtained by a less extensive operation. In this procedure, two small openings are made through the skin into the synovial sac, one above and one below the annular ligament. Through these is passed a gauze pack, which is pulled backwards and forwards many times, and then removed. By this means all the melon-seed bodies, and at least part of the synovial membrane, are removed, leaving a hand which has a useful range of function.

DISLOCATION OF TENDONS

Any tendon, which normally runs in a bony groove, may on occasion become dislocated from its bed, but the displacement occurs most commonly in the following situations.

Peroneal Tendons

Slipping of one or both peroneal tendons from the groove behind the lower end of the fibula is a comparatively common disability, and follows usually on some excessive muscular effort, during which the peroneal tendons have pulled away the attachment of the annular ligament, which normally holds them in position. The displacement may occur only on a single occasion, but recurrence is very common. Each time the foot is dorsiflexed, more especially if eversion is combined with the dorsiflexion, the tendons slip round the outer aspect of the fibula. Pain is present at the site of the displacement, and replacement of the tendons into their normal groove, which occurs with plantar flexion, is accompanied by a distinct click.

Treatment

After the first displacement, the tendons, if still out of their normal position, should be replaced by plantar flexion of the foot, and an attempt should be made to restore the torn annular ligament by fixation of the

foot in slight plantar flexion and inversion for 2–3 weeks. If the displacement has occurred repeatedly, open operation holds out the only prospect of cure.

Operation. The tendons are identified through a curved incision over the outer and posterior aspect of the fibula. A vertical incision is made through the periosteum over the anterior edge of the fibula, and by means of a chisel the outer layer of the fibula is raised with the periosteum as an osteoperiosteal flap, and turned back on the unbroken hinge at its posterior margin (Fig. 138). This osteoperiosteal flap—2 inches in width—is then sutured over the peroneal tendons on to the outer aspect of the astragalus, thereby increasing the depth of the peroneal groove.

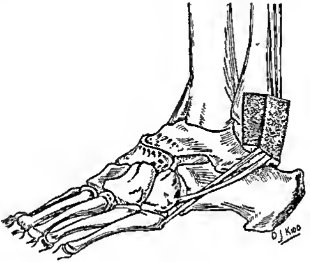


FIG 138.—Operation using osteoperiosteal flap for slipping Peroneal Tendon

Failure of the operation results from the too-early contractions of the peroneal muscles, which tear away the transferred flap. This failure can best be prevented by passing a chromic catgut suture through the raised flap, and through each of the peroneal tendons. Contraction of the muscles is prevented until the catgut has been absorbed in 20–30 days, a period which is usually sufficient to allow the protective flap to become firmly adherent. After the operation the foot is fixed in a plaster case in slight plantar flexion for at least 4 weeks, when active use may safely be permitted.

Snapping Hip

Under certain circumstances a thick muscular and tendinous mass slips across the outer side of the great trochanter on each voluntary

flexion and extension of the hip-joint. The movement is especially noticeable in thin patients, and may on occasion be accompanied by an audible snap. As a rule, the slipping is not accompanied by pain or disability, but when present in a very nervous patient it may give rise to considerable anxiety. When the movements of flexion and extension of the joint are carried out passively, no definite slipping can be detected, while the extent of the slipping and the so-called click can be greatly exaggerated if active flexion and extension of the joint are carried out with the hip in a position of adduction.

The cause of the slipping, as demonstrated by Wood Jones, is the presence of a thick tendinous band on the deep aspect of the gluteus muscles, and only in those patients in whom the condition is giving rise to mental or physical disability is treatment advisable.

Operation. The anterior border of the gluteus maximus is defined and the tendinous band identified through a vertical incision above and behind the great trochanter. It is usually sufficient to divide this band, but, in addition, in order to make a recurrence impossible, the divided band should be sutured back on itself behind the trochanter.

Clicking Hip

Another type of snapping or clicking hip is frequently encountered in athletes. Here a definite sharp click in the region of the joint occurs when the thigh is actively straightened through the last 25 degrees. The explanation of the click is doubtful; it has been suggested that it is caused by a lateral slip of the ilio-psoas tendon over the front of the hip-joint, but it more probably results from laxity of the cotyloid ligament. It seldom causes any disability or pain, although occasionally slight tenderness of the joint may be present, especially in young women.

Treatment

Fixation of the hip and thigh in a plaster-of-Paris spica for a period of 8 weeks is usually sufficient to relieve the tenderness, although, as a rule, the clicking does not entirely disappear.

Slipping of the Semitendinosus

Normally the tendon of the semitendinosus muscle is held in position behind the internal condyle of the femur by its sheath of deep fascia. If, as a result of excessive muscular effort, this retaining sheath is torn, the tendon may then become displaced each time the knee is fully extended.

In a position of flexion the tendon lies in its normal position behind the condyle, but when the joint is extended it slips round the inner border and lies in front of the adductor tubercle. The slipping is usually

accompanied by a definite click and a feeling of pain or temporary uselessness in the leg.

Diagnosis

The symptoms are quite definite—the patient states that he feels *something slipping at the inner side of the joint every time the knee is* bent or straightened. A mistaken diagnosis of internal derangement of *the joint may be made, unless the surgeon palpates the joint during these* movements, when the recurrent displacement is easily appreciated. The absence of synovitis following the clicking confirms the diagnosis.

Treatment

Any attempt at suturing the tendon into its normal position is certain to fail. All that is necessary is a simple division of the tendon, the subsequent loss of strength being so slight as to be unrecognizable.

Slipping of the Biceps Tendon

Occasionally, when the biceps femoris tendon is inserted into the neck of the fibula rather lower than normal, slipping of the tendon over the underlying head of the fibula may cause pain and a feeling of insecurity. This slipping can only be recognized when the joint is palpated during active flexion and extension. If this method of examination is not carried out, this condition also may be confused with an internal derangement of the joint.

Treatment

Through *an incision over the posterior margin of the lower part of* the biceps, its attachment to the neck of the fibula is defined. The *external popliteal nerve is retracted, the head of the fibula is roughened,* and the tendon of the biceps—which has also been roughened—is sutured *to it by deep stitches which pass through the bone and the tendon.* Fixation in extension for 3 weeks, followed by active use, restores the full range of painless movements without disability.

CHAPTER XXI

CONGENITAL DISLOCATION OF THE HIP AND OTHER CONGENITAL DISLOCATIONS

CONGENITAL DISLOCATION OF THE HIP

Complete, or partial dislocation of the hip-joint, is found comparatively frequently at birth, while a similar congenital malposition of any other joint occurs only on very rare occasions. Female children are affected much more commonly than males, the percentage being 80–85 per cent females as compared with 15–20 per cent males. The displacement occurs slightly more frequently as a unilateral than as a bilateral deformity, the proportions being 55 per cent of the unilateral type to 45 per cent in which the dislocation is found on both sides.

Causes of the Dislocation

Many ingenious suggestions have been advanced in an effort to explain the occurrence of the dislocation, but no really satisfactory explanation has yet been given and, in our desire to understand its production, we are reduced to the statements that:

1. Congenital deformities occur more commonly in females than in males.

2. In congenital dislocation of the hip there is an absence of growth of the acetabulum, particularly of its posterior superior margin.

3. Whether this absence of growth is primary or secondary cannot be proved.

4. The displacement may be caused by the too-prolonged intra-uterine *fixation of the thigh in a position of acute flexion* and adduction, causing abnormal pressure on the acetabular margin.

A familial predisposition to congenital deformity is indicated by the fact that, in 5–10 per cent of the cases investigated, there is a history of some similar congenital abnormality being present in one of the parents, or in their immediate connections.

At birth the dislocation may be either complete or partial, instances of both types having been found in new-born infants. When complete, the head of the femur lies above the level of the upper border of the acetabulum, whilst a partial displacement is indicated by the presence of the femoral head on the upper acetabular rim, a condition which is described as an incomplete dislocation or subluxation (Fig. 139). In this displacement not only is the head of the femur pressing against the upper border of the acetabulum, but it is also considerably larger than normal. It is doubtful whether a congenital subluxation is ever changed

FIG 139.—Congenital Subluxation of the Hip joint

by weight-bearing into a true dislocation, but definite slow raising of the site of the false acetabulum can be shown to occur.

ANATOMY

In the presence of a dislocation, or a subluxation, the joint structures vary considerably from the normal, the extent of the changes depending largely on the age of the patient, and on the amount of weight-bearing to which the joint has been subjected. It is obvious that a knowledge of these alterations is essential for the successful treatment of the deformity.

Before Walking. *The Acetabulum.* The acetabulum, which is covered by healthy articular cartilage, may be almost normal in size, shape and depth, but, as a rule, it is shallow and occasionally has an ovoid or triangular outline.

The Capsule. This is stretched to accommodate the displaced head of the femur, but otherwise it is normal in structure and is not constricted in any portion.

Head of the Femur. The head of the femur always lies at a higher level than normal; it may be placed directly above the centre of the acetabulum, but more frequently lies slightly behind this line The outline of its articular surface is usually normal, but occasionally it is somewhat flattened on one side, or may show a general mushroom deformity of its whole surface. The ossification of the upper femoral epiphysis on the affected side is shown by the radiograph to be considerably delayed as compared with the normal (Fig. 140).

After Walking. When the child begins to walk considerable alteration occurs in all the tissues, both bony, cartilaginous and ligamentous, and these changes progress rapidly with use of the joint.

The Capsule. In response to strain the capsule becomes stronger and considerably thickened especially on its upper aspect where it supports the head of the femur Owing to the continued pressure between the head of the femur and the outer surface of the ilium, the portion of capsule separating these two bones becomes firmly adherent to the ilium. At first the wide funnel of capsule, extending between

the acetabulum and femur, is unconstricted, but later, as a result of the continued pressure of the ilio-psoas tendon, this area shows a definite thickening and narrowing of its lumen.

The Acetabulum. The acetabulum gradually becomes filled with fibrous and fatty tissue, whilst its contour is considerably modified, the normal cup-like cavity becoming altered into a triangular-shaped depression with the apex of the triangle at the posterior superior margin. The articular cartilage loses its shiny smooth surface, becoming fibrillated and dull in appearance. Later, as a result of continued pressure of the

FIG. 140.—Congenital Dislocation of the Hip, showing delayed ossification in epiphyses of head of femur and poor shelf of acetabulum

dislocated head of the femur on the outer aspect of the ilium, a secondary false acetabulum is formed, in which the displaced femoral head attains a certain amount of stability.

The Ligamentum Teres. The ligamentum teres is gradually stretched and becomes thin and strap-like, although it is never entirely lost, even in elderly patients.

Head of the Femur. The head of the femur, lying always at a higher level than normal, may be situated directly above the acetabulum, but more commonly lies in a position above and behind the socket. This—the usual type of dislocation—is described as a posterior displacement, in contrast with the rare anterior dislocation, in which the head lies

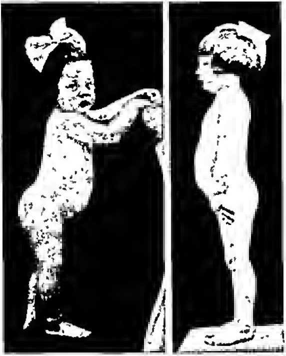
above and in front of the acetabulum. The contour of the head gradually changes, the side which lies against the ilium becoming flattened, while occasionally the whole head may assume a mushroom appearance in response to pressure between the side of the ilium and the apex of the articular surface of the femur.

Anteversion of the Neck of the Femur. At birth in a normal hip-joint, the neck of the femur inclines forwards from the plane of the shaft, this angle between the two segments being, as a rule, about 35 degrees. Under normal stress of ligamentous pressure the amount of this anteversion is gradually reduced to 10 or 15 degrees. In the presence of congenital dislocation of the hip-joint this normal ligamentous pressure is not effective, so that the original angle of inclination is left unaltered, or may be increased to 50 or even 90 degrees.

The Pelvis. Secondary changes in the pelvis soon appear. In the unilateral dislocation the affected side of the pelvis is smaller and more vertical. In bilateral dislocation both pelvic bones take up a more vertical position than normal, so that the inferior pelvic opening becomes widened and the pelvic crests approximated. With the common posterior displacement of the femoral head there is a tendency for the sacrum to tilt forwards and downwards at its anterior border, with the result that the whole bone assumes a more horizontal position. When the displacement of the head of the femur is anterior, this secondary tilting of the sacrum and of the pelvic cavity does not occur.

Muscles. On account of the displacement of the head of the femur the gluteal and rotator groups of muscles are stretched and somewhat atrophied, while the long thigh muscles, especially the adductor group, are shortened, to correspond with the approximation of their origins and insertions.

Spine. In the presence of a unilateral dislocation of the hip the pelvic obliquity, which follows on the shortening of one leg, leads to a lateral deviation of the lumbar spine, combined in most instances with a slight increase in the normal lordosis (Figs. 141*a* and 141*b*). With a bilateral dislocation, especially when the head of the femur lies behind the acetabulum, the lordosis is very greatly increased, whilst the lateral deviation is absent. This exaggeration of the normal lumbar curve is the result of the alteration in the line of weight-bearing. Normally, this line passes through the centre of the acetabulum, when the supporting pillar of the femur is displaced backwards it naturally follows that the weight of the trunk passes an equal distance in front of the acetabulum, thus the extent of the increase in the lordosis is in direct proportion to the amount of posterior displacement of the head of the femur. If, however, the dislocation of the hip is anterior, this exaggeration of the lumbar curve is entirely absent. In fact, with a double



(a) (b)

FIG. 141.—Congenital Dislocation of the Hip.
(a) Unreduced, showing lordosis.
(b) Reduced, showing normal lumbar curve.

anterior displacement of the femoral head the normal lumbar lordosis is considerably diminished, or may entirely disappear.

SIGNS AND SYMPTOMS

Very occasionally the peculiar widening of the perineum, or the shortening of one leg, may draw the parents' attention to the dislocation before the child begins to walk, but, as a rule, the child appears to be normal in every way up to the age of one year. Suspicions of the presence of some abnormality may then be aroused by the fact that the child makes no effort to stand as soon as other children, and when walking begins—usually 3 or 4 months later—the distinctive single or double limp, which is so characteristic of the deformity, draws attention to the condition.

Complaints of pain or discomfort are almost unknown during the first 15 years of life, but later, with increasing weight and strain on the hip and lumbar spine, the patient may complain of a dull aching over the lower back, accompanied, in some cases, by pain at the site of the displaced femoral head.

Examination

Shortening. In every case of unilateral dislocation the affected leg is shorter than normal. The degree of this shortening varies with the age, and with the amount of walking which has been permitted. Thus, subluxation of the hip-joint causes a shortening of the leg, which is usually limited to half an inch or one inch, even in the adult, whilst, in the case of an untreated complete dislocation in the adult, the shortening may be as much as $3\frac{1}{2}$ or 4 inches.

Telescoping. When pressure is applied to the foot, as normally occurs in weight-bearing, the displaced femoral head glides upwards on the outer aspect of the ilium. This movement, which is known as telescoping, can usually be demonstrated whilst the leg is in the extended position, but is shown more easily with the hip and knee flexed to a right angle, when, by downward pressure applied in the region of the knee, the head of the femur can be felt gliding backwards and forwards on the ilium. This movement can best be appreciated by placing one hand over the anterior superior spine of the ilium and the great trochanter of the femur, when the latter can be felt to alter its position in relation to the former on each application of pressure to the knee.

Trendelenburg's Sign. This sign is present in every condition of instability of the hip-joint, and is caused by the patient's inability to

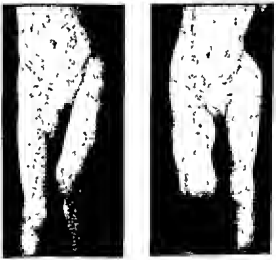


Fig. 142.—Showing dropping of the pelvis in Trendelenburg's sign

stabilize the weight-bearing hip in a position of slight abduction. Normally, when the weight of the body is taken on one leg, the pelvis rises

on the other side owing to contraction of the hip muscles, which lock the weight-bearing hip in slight abduction. *When, from any cause,* either muscular weakness, as in paralysis of the gluteal muscles, or alteration in the mechanics of the joint, as in this condition of congenital dislocation of the hip in which it is impossible to lock the head in the acetabulum, this power of fixation of the weight-bearing hip-joint is absent, the pelvis sinks on the other side, as shown in the photograph (Fig. 142).

Movements. Flexion and extension of the joint are free and complete as compared with the other side. Adduction can be performed more freely than on the normal side, but abduction is limited by a varying amount, according to the age of the patient and the amount of shortening which has resulted from weight-bearing. Rotary movements at the hip are limited, either internal or external rotation being lost, according to the position of the head of the femur in relation to the great trochanter. If the dislocation is anterior, internal rotation of the thigh is impossible, whilst external rotation is diminished or lost in the rare instances in which the head of the femur lies permanently posterior to the great trochanter.

Position of the Head of the Femur. Although all the signs may point to the probability of a dislocation of the hip, the only unmistakable sign of the condition rests on the discovery of the head of the femur in an abnormal position outside the acetabulum. By careful palpation in the region of the hip the surgeon can decide whether there is such an abnormal bony prominence present in front of, behind, or above the great trochanter. The palpation is carried out first with the hip in the extended position; then by flexion and adduction of the thigh the displaced head of the femur can usually be felt as a distinct bony prominence under the gluteal muscles.

Radiographic Appearances

These will usually make the diagnosis quite clear (Fig. 143). They show the head of the femur lying above the acetabulum, which has no definite roof as on the normal side, but shows a gradually sloping floor, extending from its centre to the outer surface of the ilium. Shenton's line also shows considerable alteration. This line is formed by continuing the curve of the lower border of the neck of the femur on to the pelvis; under normal conditions the upper border of the obturator foramen and the lower border of the neck of the femur should form one continuous curve, and any alteration in the continuity of this line indicates the presence of a structural deformity.

In very young children there may be considerable difficulty in deciding whether the head of the femur is lying in the acetabulum, or on its upper margin. Considerable help in deciding this point is gained by drawing a vertical line on the film from the upper and outer border of the aceta-

FIG. 143—Congenital Dislocation of both hips with a good acetabular shelf.

bulum. If the head of the femur is in its normal position its epiphysis lies internal to this line, whereas in congenital dislocation of the hip the line passes internal to the epiphyseal cap In congenital subluxation of the hip the relation of the epiphyseal cap and the vertical line are not constant, the line, as a rule, running through the epiphysis, although in some cases the arrangement is similar to that in congenital dislocation.

Differential Diagnosis

Little difficulty is experienced, as a rule, in making the differential diagnosis. The only conditions likely to be mistaken for congenital dislocation of the hip-joint are:

1. Suppurative Arthritis of Infants. Acute septic infection of the hip-joint occurs comparatively frequently in children during the first year of life. The onset is sudden, the child is extremely ill with a temperature of 103–105 degrees, and very soon a large abscess is discovered over the region of the joint. After opening the abscess, discharge from the wound usually lasts for a few weeks, and the child then appears perfectly normal. Later it is discovered that the leg on the affected side is shorter than the other and that an abnormally free range of movement is present in the joint. Radiographs show a complete loss of the head and part of the neck of the femur (Fig. 38), which accounts for the increasing shortening and abnormal mobility. The deformity resulting from such a destructive arthritis may be recognized by the abnormally free joint movements, by the radiographs, which show absence of the head and most of the neck of the femur, by the presence

of a scar over the affected joint, and by the surgeon's inability to palpate the head of the femur. This clear-cut clinical picture of the end result of a destructive suppurative arthritis occurring in an infant is considerably modified by the use of penicillin in the acute stages of the disease. Following this line of treatment, the destruction is much reduced, the head of the femur may be wholly or partially preserved, and the stability of the joint to some extent retained.

2. Coxa Vara. Coxa vara, in which the great trochanter is also raised above the normal, may be recognized easily by the absence of telescoping, by the greater loss of the power of abduction of the thigh, and by the presence of the head of the femur in the acetabulum. The radiographs confirm the clinical diagnosis.

3. Paralytic Dislocation. Dislocation of the hip-joint due to infantile paralysis may cause some difficulty in diagnosis. The dislocation never follows a complete paralysis of all the muscles, but is usually found when the gluteal group are paralysed, while the adductor muscles remain active. The thigh is pulled into adduction and the capsule is gradually stretched and weakened over the posterior aspect, until the femoral head becomes dislocated at this point. The condition can be recognized by the localized loss of power, by the history, and by the radiographic appearance of a normal acetabulum and a normal femoral head.

4. Congenital Shortening of the Femur. Congenital shortening of the limb due to absence of growth of the whole, or part of the femur, may give rise to some difficulty in diagnosis. The signs of shortening and telescoping of the limb may be very similar to those given by a congenital dislocation of the hip, but on examination the whole femur is found to be shortened as compared with the other side. Occasionally part of the femur does not develop; this absence may involve the head and trochanteric region alone, or may extend to the lower third of the bone. As a rule, the condyles of the femur, at least, are visible in the radiograph (Fig. 144),

FIG. 144.—Congenital Shortening of the Right Femur.

the lower end of the femur never being absent when the upper section of the bone is present.

Treatment of Congenital Dislocation of the Hip

This may be divided into four sections:

1. Closed reduction.
2. Open reduction.
3. Reconstructive operations.
4. Corrective operations in old cases.

Fig. 145.—Perthé's Disease of the Head of the Femur following congenital dislocation of the Hip joint

Closed Reduction

The results obtained through this line of treatment depend largely on the age at which it is carried out, and the amount of trauma inflicted on the tissues during the course of the operation (Fig 145). It was formerly held that the reduction of the dislocation was most satisfactory when carried out between the ages of 2 and 2½ years. This impression probably arose from the difficulty experienced in keeping the plaster casts dry in these young children, but the work of Putti has proved definitely that the earlier the reduction the better the prognosis. It is only on very rare occasions that the surgeon has the opportunity of treating a child suffering from a congenital dislocation of the hip-joint before walking has taken place, but, if discovered at this early age, treatment

is extremely simple, reduction of the dislocation usually following on full abduction of the hip, which is accomplished simply and without trauma by the application of Putti's mackintosh-covered triangular wedge.

The object of the earliest possible reduction is the stimulation of growth of the acetabular margin which follows on the presence of the head of the femur in the acetabulum. Unless the acetabulum is occupied by the head of the femur its upper margin tends to atrophy, but when reduction is completed the acetabular rim steadily increases in depth.

Up to the age of 3 years little difficulty is experienced in reduction of the dislocation. Under full anæsthesia, with the child supine and the hip and knee flexed to right angles, the thigh is grasped above the knee, while the pelvis is fixed with the other hand. Extension on the thigh is now made in an upward and inward direction, and the thumb of the hand holding the pelvis is used to press the head of the femur over the posterior-inferior border of the acetabulum, the leg only then being abducted with the object of retaining the head of tha bone in the acetabulum. Between the ages of 3 and 5 years, considerably greater difficulty is experienced in reduction. Occasionally it is advisable to have a preliminary stretching and loosening of the hip by means of continued pull on a Thomas bed knee splint for a period of 2–4 weeks. When reduction is then attempted the same manœuvres are carried out with the help of an assistant, who pulls the leg in a position of acute adduction and flexion, while the surgeon uses both hands to control the pelvis and both thumbs to lift the head of the bone into the acetabulum (Fig. 146). When reduction is completed the stability of the acetabulum can be gauged by redislocation and reduction, which are easily accomplished. The leg is now slowly stretched into full abduction with the hip and knee at right angles, in order that the tightened adductor muscles and anterior part of the capsule of the joint may be stretched sufficiently to allow the femur to remain in the acetabulum. After the resistance offered by these contracted tissues has been overcome, the lateral abducting pressure is removed and the limb left free, when it will usually be found that the thigh remains in a position of about 45 degrees' abduction and right-angled flexion, with internal rotation. This position into which the leg and thigh have naturally fallen without redislocation is that at which the head of the femur is placed at the deepest part of the acetabulum, and is the position in which the hip-joint should be fixed for at least 12 months. The fixation is most effectively obtained by means of a plaster-of-Paris case, extending from the lower ribs to the calf of the leg. The routine commonly adopted of using three separate plaster cases, the hip-joint in the two latter being at a somewhat more extended angle than the first, was introduced largely owing to the fear of rigidity following the prolonged fixation.

This rigidity, however, is not due to the fixation, however long continued, but occurs only in older children, where the efforts at reduction have produced a traumatic arthritis, and its appearance need not be feared in children under 5 years of age, if the reduction is carried out gently and without undue force. It is essential to retain the hip in the position *in which the head of the femur lies in the deepest part of the acetabulum*, as the stimulus to the growth of the bony rim of the acetabulum is greatest when the head of the femur lies in its normal position. After at least 12 months' fixation the plaster case is removed, and exercises—

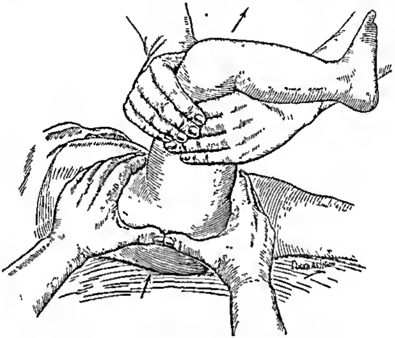


FIG. 146.—Showing Reduction of Congenital Dislocation of the Hip.

combined with massage and *gentle stretching—are given for 2–3 months* before walking is allowed. No difficulty is usually experienced in the restoration of the full range of movements, after which normal use of the limb is permitted

In favourable cases redislocation does not occur, the hip feels stable, Trendelenburg's sign has disappeared and the radiographs show the development of the upper part of the acetabulum, which in time can be differentiated from normal only with considerable difficulty (Fig. 147). The percentage of successes following this operation depends very largely

FIG. 147.—Congenital Dislocation of Left Hip
(a) Unreduced

on the age at which reduction has been carried out, the gentleness with which the manœuvre has been performed, and the efficiency with which the correction has been maintained during the 12 months of fixation. If reduction is completed before 2½ years of age successes amount to 80 per cent. This figure rapidly diminishes with increase in the age of the patient, until at the age of 4½ years only 45-50 per cent good

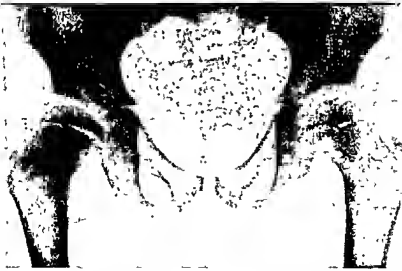


FIG. 147.—(b) 4 years after Reduction, showing good hip formed by natural means.

results can be obtained by the use of the closed method of reduction. Failure of the growth of the acetabular margin following the reduction accounts for the large majority of unsuccessful results, and this failure is soon recognized by continued instability of the joint and the reappearance of the dislocation. If a redisplacement has occurred, and it has become evident that success is unlikely to follow the use of the closed method of treatment, no time should be lost in again reducing the dislocation and performing a reconstruction operation on the upper border of the acetabulum.

Reconstruction Operation. The hip-joint is most easily approached through the Smith Petersen incision; *in this the skin is incised along the* anterior third of the crest of the ilium, and from the anterior superior spine almost vertically down the thigh for 4 or 5 inches. The interval between the sartorius and tensor fascia femoris muscles is sought, and the skin incision along the crest of the ilium is deepened until the muscle attachments to the bone at this point are completely severed. In this way the gluteal muscles and tensor fascia femoris are freed from their attachment to the iliac crest. The space between the tensor fascia femoris and sartorius is now widely opened up, and a free exposure of the hip-joint is obtained by completing the separation of the gluteal muscles from the ilium by means of a blunt dissector. The capsule of the hip-joint is now freely exposed above, in front and behind, when it will be found that traction on the extended leg brings the head down to the site of the acetabulum. The capsule, which is usually adherent to the ilium above the normal acetabulum, must be freed by blunt dissection, and the limits of the original cavity clearly defined from the adjacent false socket. If the head of the femur can be placed in the acetabulum, *opening of the joint cavity is unnecessary and inadvisable*, but if, because of the presence of a mass of fibrous and fatty material in the joint, such close approximation is impossible, the capsule should be opened and the fibro-fatty mass removed. It may be stated as a guiding rule that opening of the joint cavity should be avoided if possible, as the resulting hæmarthrosis may cause some diminution of movement and a considerable prolongation of the after-treatment.

After reducing the dislocation a large curved flap of bone is raised from the ilium round the upper, anterior and posterior margins of the acetabulum. This flap is so designed (Fig. 148) that the living hinge of bone is placed at, or slightly below, the margin of the normal acetabular cavity and should never be formed above this level. When levered out above the head of the femur it replaces the absent acetabular margin, and it can be retained in this position by means of bone wedges taken from the outer layer of the ilium, above and behind the acetabular region, or from the crest of the ilium. These bone flaps, or wedges, should be reinforced by multiple bone chips, which are used to pack

any vacant spaces. If properly designed the bone flaps require no pegging or wiring in position. The gluteal muscles are now sutured back to the iliac crest by a series of deep stay sutures, and the wound sewn up without drainage.

Traction on the leg must be continued during the whole course of the operation and also during the after-treatment, so that the head of the femur is pulled down to the lower border of the acetabulum, and pressure

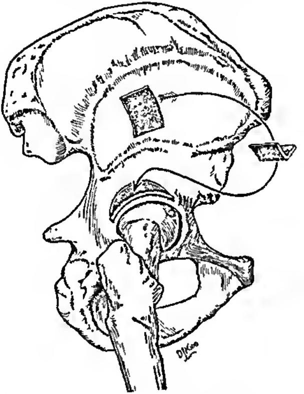


Fig. 148.—Shelf operation for Congenital Dislocation of Hip with poor acetabulum.

on the newly formed rim is prevented until consolidation is complete. This relief of pressure from the upper margin is obtained most readily by the use of a simple weight and pulley extension, or by the application of a Thomas frame in which traction can be employed. By using traction the results obtained are better than those which follow the application of a plaster cast, in which it is impossible to prevent continuous pressure of the head of the femur on the soft, newly-formed acetabular rim.

Open Reduction

The operation of open reduction of a congenital dislocation of the hip-joint has been advised by some surgeons as a routine method of

treatment because of their belief that, in many instances, the presence of a constriction of the capsule *prevents complete reduction of the head* of the femur. In performing the reduction the joint is defined through the same approach as that used for the reconstruction operation, or through a straight anterior incision. When the region of the joint has been cleared the reduction is easily completed, and if the capsule is already adherent to the ilium above the acetabulum, it should be separated from the bone by blunt dissection without opening into the joint cavity. The results obtained by this method of open reduction do not justify the increased risk entailed by the operation, and the procedure is not necessary or advisable in the younger patients. Open operation and deepening of the acetabular cavity has been advocated by *several authorities. The operation, which necessitates the wide* removal of the articular cartilage and deepening of the acetabulum, combined usually with an osteotomy of the trochanteric region of the femur, has no advantage and many disadvantages when compared with closed reduction.

Fig. 149.—Dislocation of the Hip with the head anterior, showing normal lumbar curve.

Patients between 7 and 14 years of Age

Although it is possible on many occasions to reduce a congenital dislocation of the hip-joint in a patient of 10 or 12 years of age, such reductions are usually followed by the development of arthritis with considerable limitation of movements in the joint. *The causes of this rigidity may be classified* as:

1. Irregularity of the head of the femur.
2. The trauma necessary for reduction.
3. Excessive pressure of the femoral head on the acetabulum after reduction.

It may be taken, as a rule, that after 7 years of age the reduction of a congenital dislocation of the hip is inadvisable and should not be attempted. When a patient over this age is seen suffering from congenital dislocation of the hip there are certain *lines of treatment* possible, and each must be considered. The measures which should be employed vary with certain factors, of which the most important is the position of the displaced femoral head.

1. With anterior dislocation.
2. With posterior dislocation.

1. *With Anterior Dislocation*

Here the head of the femur lies above and in front of the acetabulum and under the strong

Y-shaped ligament of Bigelow and ilio-tibial band of fascia lata. Because the head is held so firmly in position, shortening of the leg never exceeds $1\frac{3}{4}$ inches, even in adult life, as compared with $3\frac{1}{2}$–5 inches so commonly found with posterior displacement. With anterior displacement also there is no tendency to increase of the normal lordosis, and the patient stands straight and does not complain of aching in the lumbar region of the spine (Fig. 149). For these reasons, attempts at reduction of the dislocation are inadvisable, and even though it may be possible to place the head of the femur in the acetabulum, redisplacement is almost inevitable.

2. *With Posterior Displacement*

Because of the increasing shortening of the limb and the extreme lordosis, which so commonly follow on unreduced posterior dislocation, an attempt to transfer the head of the femur to the anterior aspect of the acetabulum is advisable. This alteration of the position of the femoral head is usually possible up to the age of 8–10 years. In order to carry out this alteration of position extension is applied to the limb for 4 weeks. The head of the femur gradually descends on the side of the ilium, the rate of descent depending on the age of the patient and the rigidity of the tissues. When the fullest possible correction of the position has been obtained the child is placed on a hyperextension frame, by which the hip is forced forward and the thigh backward. As a rule, anterior displacement of the head of the femur can be produced by this simple method of hyperextension, and following the alteration the limb is retained in the same position for a period of 4–6 months.

Formation of a False Socket. The stabilization of the head of the femur by the formation of a false acetabulum in a position of deformity is never advisable. Such a procedure is not necessary, or even possible, when the head is anterior to the acetabulum, and, if a new false acetabulum be formed over the posterior part of the ilium in the position in which the displaced femoral head normally lies, the operation simply results in making permanent the shortening of the leg and the excessive lordosis of which the patient will eventually complain.

Operative Treatment in Old Unreduced Dislocations (Fig. 150)

In the young child suffering from congenital dislocation of the hip, treatment is planned towards the reduction of the dislocation and the retention of the head of the femur in its normal position. In the adult such reduction is, as a rule, impossible, and the aim of treatment must then be the relief of pain, either in the region of the displaced femoral head or in the lumbar spine, where it results from the increased lordosis.

Pain over the site of the femoral head is caused by the excessive strain thrown on the ligaments and muscles supporting the head in this abnormal position, and only very occasionally by the development of a traumatic arthritis at the false joint.

FIG. 150.—Old unreduced Congenital Dislocation of the Hip.

The increased lumbar curve is the direct result of the transposition backward of the weight-bearing pillar of the femur from its normal situation in line with the middle of the acetabulum. If the femur can be transferred forward to the line of the acetabulum, the lordosis disappears, whilst if, at the same time, the excessive pressure on the

tissues over the displaced femoral head can be reduced by increasing the weight-bearing surface of the upper portion of the femur, relief of pain, is inevitable. This double object of reduction of the excessive lordosis and broadening of the weight-bearing area follows on a simple osteotomy of the femur, or on the bifurcation operation of Lorenz, success in either being dependent on the presence of movement at the false joint.

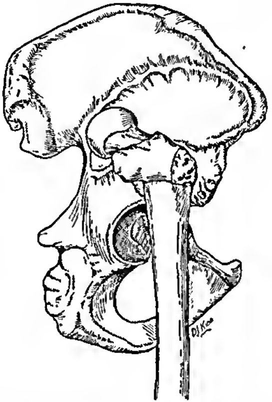
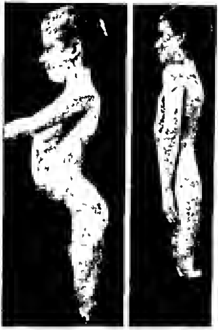


Fig. 151.—Operation of Sub-trochanteric Osteotomy for unreduced Congenital Dislocation of the Hip, showing shaft displaced forwards and a normal line of weight-bearing.

Femoral Osteotomy. In old unreduced dislocations a subcutaneous osteotomy of the femur is performed at the level of the acetabulum; the site of division of the bone is, therefore, not a fixed point, but depends on the amount of elevation of the head of the femur above the acetabulum. When the osteotomy is completed the thigh is hyper-extended to 45 degrees, and slightly abducted at the site of fracture, and fixed in this position in a plaster-of-Paris case until union of the fracture is complete and solid. The thigh is now brought down into the



(a) (b)

FIG. 152.—Congenital Dislocation of the Hip in a boy aged 13, showing (a) marked lumbar lordosis; (b) normal lumbar curve after Sub trochanteric Osteotomy

straight line, which causes the upper fragment to lie in an apparently horizontal position (Fig. 151). By this means the weight-bearing surface has been very greatly increased, and the amount of pressure applied to the head of the femur is correspondingly reduced. In addition, because of the anterior replacement of the shaft of the femur, the excessive lordosis disappears with a reduction of the lumbar strain (Fig 152).

Lorenz Bifurcation. This operation, of which the basic principles vary little from that of the previous method, consists in the transference of the shaft *of the femur* to the region of the acetabulum. The femur is divided by an oblique osteotomy, extending from below upwards and inwards, so placed that the upper pointed end of the lower fragment lies at the level of the acetabulum. The divided segments are now separated and the upper end of the shaft is pushed forwards and inwards against the capsule covering the acetabulum (Fig. 153). The whole limb and pelvis are now immobilized in a complete plaster case in a position of 35 degrees' abduction. This is retained until union between the two femoral fragments has been obtained.

The two operations are to a large degree similar. In the Lorenz Bifurcation the aim is the support of the body on the Y-shaped upper portion of the femur, whilst in the simple osteotomy weight is borne through the upper femoral fragment, which forms a right angle with the shaft, and does not tend to cause as much irritation in the region of the old acetabulum as follows the bifurcation operation.

Arthrodesis of the Hip-joint for Unreduced Dislocation. If *arthrodesis of the hip is considered advisable it should only be employed* after reduction of the head of the femur into the original acetabulum or its close proximity. If the operation is carried out whilst the head is placed on the dorsum ilii, there can be no diminution of the lordosis,

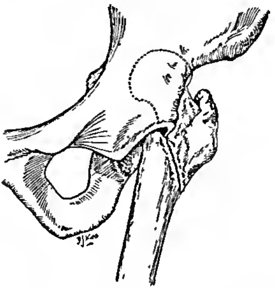


FIG. 153.—Lorenz Osteotomy for unreduced Congenital Dislocation of the Hip, showing shaft transferred into acetabulum, bony union has taken place.

and the discomfort caused by the deformity is increased rather than diminished by this operative procedure.

Prognosis

Untreated congenital dislocation of the hip-joint, whether unilateral or bilateral, causes little or no discomfort during the first 15 years of life. Later, with increasing weight, aching in the back develops steadily, associated with vague abdominal discomfort. Pain over the dislocated femoral head is a very constant sign, although it often develops at a later date to the lumbar aching. The pain in this situation is caused, either by stretching of the gluteal muscles, the capsule and ligaments of the hip-joint, or by the development of an arthritis in the false joint, and either condition may necessitate extensive surgical interference.

If treatment is instituted at an early age, these dangers are avoided and a successful result can be obtained in a very large proportion of patients, leaving a joint which is normal in function and often indistinguishable from the unaffected joint by clinical or on radiographic examination.

The success of treatment depends on several factors, of which the most important are:

1. Age. If treatment is instituted at an early age before extensive alterations have occurred in the bony and ligamentous structures of the joint, a successful result is probable, but the proportion of successes to

failures in treatment diminishes with increase in the age of the patient. Although no definite age can be given as the limit beyond which success in treatment by the closed reduction is impossible, it may be taken, as a rule, that after the age of 6 years a successful result following this line of treatment is improbable.

2. TRAUMA. Reduction of the dislocation of the joint, by whatever method it is attempted, is always accompanied by a certain amount of trauma. If this trauma is severe it may lead to injury of the upper femoral epiphysis of the ligaments of the joint or of nerve tissues, thereby diminishing the possibility of a successful result. The greatest gentleness must always be used in the reduction of the dislocation, and, as a rule, the younger the patient the less will be the trauma involved.

3. POSITION OF THE DISPLACED HEAD OF THE FEMUR. The possibility of a successful result of treatment depends to a considerable extent on the position taken up by the dislocated head of the femur. In the usual position, in which the head is displaced upwards and backwards, the results of replacement are excellent, and, if the displacement is treated within the first 4 years, at least 75 per cent of cures can be expected.

When the displaced head lies directly above the acetabulum the results are less satisfactory, the average being 65 per cent successes. The reason for this difference in the results is hard to explain, but probably the presence of the head of the femur in the region of the upper border of the acetabulum prevents the development of this margin of the socket and so predisposes to failure. With the rare anterior displacement of the head, the results of reduction of the displacement and retention of the head in the acetabulum are not so good as with either of the other two types. Although replacement of the head in the acetabulum is comparatively easy, retention in this position is much more difficult, and redisplacement occurs in 50 per cent during the period of fixation, or after removal of the plaster case. This comparative failure is probably caused by the presence of extreme anteversion of the neck of the femur in these anterior displacements. The head is twisted forwards to such a degree that retention is only possible after a complete internal rotation of the thigh, a position which is difficult to maintain over a long period.

Although redisplacements are more common with anterior dislocations, the result of such an accident is not so grave as with posterior displacements, as the shortening of the leg consequent on an anterior displacement of the femur is less and the lordosis is absent.

CONGENITAL DISLOCATION OF THE KNEE-JOINT

The term congenital dislocation of the knee is used loosely to include also congenital hyperextension of the joint, true congenital dislocation

being an extremely rare deformity. In both, the cause of the deformity is in all probability a mal-position in utero. The joint is hyperextended, the condyles of the femur can be felt abnormally prominent posteriorly, and, in the true dislocation, the finger can be placed on the anterior part of the upper articular surface of the tibia as it lies below the very minute patella. At birth the lower articular surface of the femur and the upper surface of the tibia are normal in shape, but after a few years there is a considerable alteration in outline in response to the uneven pressure, the posterior part of the tibia and the anterior margin of the

FIG. 154.—Congenital Dislocation of Knee.

femur becoming flattened with overgrowth in each case of the section which is free from weight-bearing (Fig. 154).

The chief obstruction to correction of the deformity lies in the contraction of all the segments of the quadriceps femoris muscle, particularly of its rectus femoris portion. On account of the hyperextension the tendons of the hamstring muscles are usually displaced round the sides of the femur, and by their position tend still further to hyperextend the joint. By radiographic examination it is a simple matter to differentiate hyperextension from true dislocation, in which the head of the tibia can be seen to lie partially or completely in front of the lower end of the femur.

Treatment

When the condition of hyperextension or true dislocation of the joint is recognized in the very young child, improvement of the position, or even a restoration to normal, may be produced by regular passive daily flexion of the joint. When the joint has been flexed a few degrees it is fixed in this corrected position by splint or plaster cast until the following day, when the same process is repeated and some further flexion obtained. Full flexion of the joint can, as a rule, be obtained in a few weeks, but in the older children, and occasionally when the dislocation is complete, this simple method is not sufficient, and operative correction is necessary.

Operation. Through a vertical incision above the patella the central tendinous portion of the quadriceps extensor is defined, together with the lower portion of the rectus femoris muscle to which it is attached. The tendon and the lower part of the rectus muscle are now elongated by a Z-shaped division, which permits the restoration of the normal position of the femur and tibia by simple flexion of the joint. It is not necessary to lengthen the vasti muscles or interfere with the tendons of the hamstrings, which slip round the inner and outer condyles into their normal position on the posterior aspect of the joint. Fixation of the knee at right angles is then continued in a plaster-of-Paris case for 8 weeks, *following which exercises and massage rapidly restore full* extension of the joint.

Prognosis

The prognosis depends largely on the presence or absence of normal articular surfaces on the lower end of the femur and the upper end of the tibia. If these are normal, a full range of movement may be restored to the joint, but, when the posterior part of the articular surface of the femur is absent or flattened, only a limited range of flexion can be obtained by even the most perfect correction.

CONGENITAL DISLOCATION OF THE PATELLA

This rare deformity, which may be unilateral or bilateral, is usually associated with a diminution of growth of the external condyle of the femur and with genu valgum deformity. It should be treated similarly to the acquired deformity, the success of treatment depending largely on the age at which correction is obtained. The possibility of a successful result diminishes rapidly as the patient grows.

Congenital dislocation may be found also at the *shoulder, ankle or elbow*, but these deformities are seen so rarely that they do not merit separate descriptions.

CHAPTER XXII

CONGENITAL DEFORMITIES

TALIPES

The generic term "Talipes" is commonly used to describe the group of congenital foot deformities occurring at the ankle or tarsal regions. Of these, there are a great variety of types, one of which, talipes equino varus, forms such a large proportion of the whole that it is generally described as congenital club foot.

TALIPES EQUINO VARUS

Although this deformity may develop at a later age in a patient previously normal, it almost invariably occurs as a congenital abnormality, either alone or associated with some other error of growth, such as spina bifida, or spina bifida occulta. According to statistics the deformity is found slightly more frequently in boys than in girls, the difference being about 7 per cent. Heredity is certainly a factor in its occurrence, and of the many theories which have been advanced as to its cause, probably the most reasonable is that of abnormal intra-uterine pressure, the result of insufficient liquor amnii, but no really satisfactory explanation has yet been advanced.

ANATOMY

When the deformity is present the foot is inverted, plantar flexed and adducted at the mid-tarsal joint, the position of deformity being maintained at first solely by contraction of the flexor and adductor muscles, and of the soft tissues on the inner side of the ankle and sole of the foot. At this early period there are no changes in the shape of the bones of the ankle or foot. The flexor muscles of the toes and the tibialis posticus, whose tendons run behind the internal malleolus, are contracted; their opponents—the common extensors of the toes and the peronei—on the dorsal and outer aspect of the foot are consequently overstretched. The internal lateral ligament is thickened, more especially its anterior fasciculus, which blends with the contracted and thickened inferior calcaneo-scaphoid ligament. These two structures, together with the contracted plantar fascia, form the chief bar to the reduction of the deformity. The posterior portion of the internal lateral ligament is weak and atrophied, while the middle fasciculus, which is attached to the os calcis, is also contracted, helping to maintain the adduction of the heel.

Although at this early stage the bones of the tarsus are normal in shape, there is considerable discrepancy in their relative position; thus

the scaphoid is displaced downward and inward on the head of the astragalus and is held in this position by the overdevelopment of the ligamentous mass on the side of the foot. Following on the persistent equinus position of the foot, the body of the astragalus escapes from its normal situation between the malleolei, becoming so enlarged in comparison with the intermalleolar space that its subsequent replacement is difficult, or even impossible. The neck of the astragalus retains its fœtal arrangement and points inwards from the body at an angle greater than normal, while the os calcis is plantar flexed and tilted, its inner tuberosity approaching the internal malleolus. If the child has walked on the deformed foot, the outer tarsal and metatarsal bones become enlarged in comparison with those on the inner aspect, which

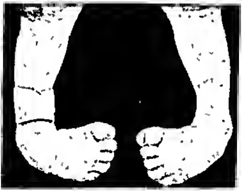


FIG. 165.—Congenital Club Foot

do not reach their normal size The calf muscles are contracted, and, on account of the inversion of the os calcis, the tendo achillis acts as an invertor of the foot rather than a pure plantar flexor (Fig. 165).

Although the deformity is usually confined entirely to the tarsus below the ankle-joint, occasionally there is, in addition, a rotation deformity of the whole leg from the knee downward, the lower end of the fibula lying in front of its upper end, while the internal malleolus lies slightly posterior to the internal tuberosity of the tibia. When the child has walked, secondary alterations are found, of which the most common are the development of callosities and bursæ over the prominent bones on the outer aspect of the foot.

Prognosis

In the absence of efficient treatment increase of the deformity is inevitable, but, if started early and carried out intelligently, treatment should always result in a cure of the deformity and the provision of a shapely, painless foot. Clinically, the amount of difficulty which is

likely to be experienced in the correction of the club foot can be judged by the degree of adduction deformity, and by the size of the heel. When the heel is small and the mid-tarsal adduction is extreme, correction is always difficult, and is possible only following a long period of manipulative correction, and possibly an open operation.

Differential Diagnosis

Congenital club foot must be differentiated from a very similar deformity which may follow on infantile paralysis; the differentiation is made by the history of a preceding febrile illness, and by loss of power and wasting in the extensor and peroneal muscles of the leg.

An almost identical deformity is seen following the *Peroneal Type of Muscular Dystrophy*, although very similar in appearance the history of gradually increasing disability, combined with paralysis, or paresis of the peroneal and extensor muscles, gives a clue to the diagnosis. *Epiphyseal Injuries*, especially those involving only the inner half of the lower tibial epiphysis, may produce a secondary deformity very similar to that of a congenital club foot.

Treatment

The successful treatment of talipes equino varus involves not merely the correction, but the over-correction of the deformity and the retention of the foot in the over-corrected position until the tendency towards relapse has been overcome. It is essential that the utmost gentleness be used at every stage of the correction; a start may be made when the child is a few days old, the ankle being held firmly in one hand to protect the epiphyses of the tibia and fibula, while the foot is slowly and gently abducted and dorsiflexed. These movements should be carried out two or three times daily until the child is at least 3 or 4 weeks old, when some form of retentive apparatus should be used.

In correcting the deformity attention should be given to its two sections: (1) the adduction at the mid-tarsal joints, and (2) the equinus and inversion of the heel.

In order to correct the adduction, the front of the foot must be abducted and dorsiflexed while the heel is fixed. It is therefore evident that the adduction at the mid-tarsal joint should first be corrected before attempting to stretch the contracted calf muscles, and before any attempt is made to bring the foot into dorsiflexion. In moulding the foot great care should be taken to avoid injury to the epiphyses of the tibia and fibula and to the ligaments on the inner aspect of the knee-joint. If the knee is not protected, a severe degree of knock-knee deformity may result from the continued stretching of its internal lateral ligament. Its protection is comparatively simple if the moulding is undertaken with the knee at right angles and the hip in external rotation.

The amount of force necessary for the correction of the deformity depends largely on the age at which the operation is attempted. In the young baby over-correction can easily be obtained by moulding with the hands, one hand protecting the ankle and tibia while the correction is carried out by the other. When the child is older, and the resistance to correction is greater, the use of a simple rounded wooden wedge will often enable the surgeon to complete the correction, which was impossible by the use of the hands alone.

At a still later stage, when there is even greater contraction of the tissues, correction of at least part of the deformity can be obtained by means of the Thomas wrench. First the jaws of the wrench are firmly clamped on the foot in the desired position and the corrective pressure applied by the surgeon's side, both hands being used to protect the ankle and knee and to prevent any possible injury to the skin or soft tissues. If complete correction in one stage is impossible, it is much better to mould on several occasions rather than risk injury to the foot or ankle by excessive violence. Occasionally, it is found that, even after efficient and long-continued stretching, the foot cannot be dorsiflexed without an elongation of the tendo achillis. This division must never be undertaken until correction of the adduction deformity of the foot is complete. If the tendon is divided before this stage, subsequent correction of the tarsal deformity is impossible.

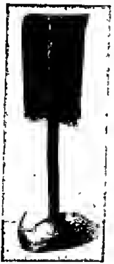


Fig. 156.—Club Foot Shoe, showing eversion of sole plate, distinguishing it from a right angled foot splint.

When the correction has been completed, some form of retentive apparatus should be applied. In very young children strapping of the foot in eversion and dorsiflexion is usually sufficient. This method has, however, the disadvantage of irritating the skin if it is continued over a long period, and it should be used only as a temporary measure in small children.

When the child has reached the age of 4 weeks it is possible and advisable to maintain the correction by the use of a splint. The two splints in common use are the Jones club foot shoe (Fig. 156), in which the foot is efficiently held in dorsiflexion and abduction, but with the disadvantage that the internal rotation of the leg on the thigh cannot be controlled.

The splint designed by Dennis Browne aims at correcting both the adduction of the foot and the internal rotation of the leg. It is composed of two foot pieces joined by a cross-bar, the pressure of one foot tending to preserve the correction of the

other. Readjustment and reapplication are required about once a fortnight, and the mobility permitted in the splint prevents muscle disuse and atrophy. The splint should be worn for about 9 months, after which the foot pieces are replaced by open-toed boots, which in turn are locked to the cross-bar to preserve the correction.

A more complete fixation can be obtained by the use of a plaster cast, extending from the toes to the middle of the thigh, the knee being bent to right angles to maintain the cast in position (Fig. 157). The method is simple; the foot is first over-corrected by moulding under anæsthesia, and the cast applied, retention in this position being maintained for about 6 weeks before reapplication is necessary. When correctly applied the foot remains in dorsiflexion, abduction and external

(a) (b)

FIG. 157 (a and b)—Club Foot in plaster after moulding.

rotation, thus correcting each section of the original deformity. When the cast is finally removed, usually when the child is about 9 or 10 months old, the normal muscle development is rapidly restored by massage and exercises, the correction being maintained by the use of night splints.

Freedom from all retention should be allowed only when the extensor and peroneal muscles are active and can pull the foot into dorsiflexion and eversion. When this voluntary power is present the tendency to recurrence has ceased, and complete freedom from restraint can be allowed with confidence (Fig. 158).

When treatment has been neglected, or has been unsuccessful, and it is evident that correction by manipulation alone is impossible, restoration of the normal shape and position of the foot can be secured by open

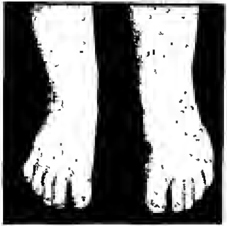


FIG. 158.—Club Foot corrected.

operation. If the deformity is caused by contraction of the soft tissues alone, and not by any alteration of bony structure, division of the contracted tissues may be sufficient; but if bony alterations are already present, correction obtained by division of contracted tissues is followed rapidly by recurrence of the deformity.

Operative Treatment. Several types of operation on soft tissue have been described. Of these that of Ober and Elmslie is probably the simplest and most efficient. Through a curved incision behind and below the internal malleolus, the plantar fascia is stripped from its attachment to the under surface of the os calcis. The deltoid ligament is then removed from the internal malleolus; the tendon of the tibialis posticus is defined, and its slips of insertion are divided separately, with the exception of the portion attached to the scaphoid. The calcaneo-scaphoid, astragalo-scaphoid ligaments and, if necessary, the posterior portion of the capsule of the ankle-joint are in turn divided, and the foot moulded into the desired position of correction, which is indicated by the appearance in the field of operation of the lower border of the articular surface of the head of the astragalus.

After the operation the foot is fixed in a plaster cast at right angles for 3 weeks, and on removal of the stitches further correction may be easily and safely obtained, and a further retentive cast is worn for at least 8 weeks. The risk of recurrence of deformity can be minimized by the wearing of suitable night splints

When the bone deformity is already present the inequality between the inner and outer aspects of the tarsus must be reduced by some form of reconstructive operation, of which the simplest is

Enucleation of the Tarsus. The operation of enucleation, or remodelling of the tarsal bones, has given excellent results, and has not been followed by the rigidity which accompanies the more extensive *operations on bone.* The operation has unfortunately a very limited application. The best results are obtained if it is employed when the child is about 6 months of age. If attempted at a later period the result is always unsatisfactory.

The procedure is extremely simple; through three small puncture wounds on the dorsum and outer aspect of the foot, an opening is made

into the cancellous tissue of the astragalus, cuboid and os calcis. With a small spoon the cancellous tissue is removed from the centre of the cuboid, from the head, neck and anterior portion of the body of the astragalus, and from the front and outer aspect of the os calcis. After removing the cancellous tissue, the foot can be easily moulded into the normal position, the correction taking place by alteration in the shape of the three eviscerated bones. Following the correction of position, the foot is fixed in a plaster cast for 2 weeks, and then remoulded into slight over-correction and retained in this position for a further 6 weeks, when all apparatus can be removed.

The results of the operation are excellent, movement is retained in all the tarsal joints, and the rigidity which usually follows operations on the tarsus is avoided.

In the older patient, when extensive bony alterations are present

FIG. 159.—Old untreated Club Foot, showing Tendon Achilles acting as an invertor of the foot.

(Fig. 159), correction can only be obtained by the removal of a wedge of bone from the outer and dorsal aspect of the tarsus, or by a reconstruction operation, such as that of Dunn.

Bone Wedge. Before removing a section of bone from the foot, all possible correction of the deformity must be secured by moulding, and if necessary by division of contracted soft tissues. After the moulding, a wedge of bone is removed through an incision on the upper and outer aspect of the tarsus, the base of the wedge being on the convex aspect of the tarsus, and its apex on the inner border of the foot, the size of the wedge varying with the degree of deformity. In its course, the line of section cuts across several of the intertarsal joints, and, whilst this division interferes to some extent with the subsequent mobility of the foot, the functional result is good.

Following the operation the foot is fixed in slight over-correction in a plaster case for at least 8–10 weeks until consolidation has occurred.

Retention of the correction is here dependent on bony fusion and redeveloped muscle power, but the use of night splints is advisable for at least 3–6 months.

Reconstruction. In neglected or relapsed cases with severe deformity full correction may be obtained by the reconstruction operation of Dunn, by which the normal shape is restored, while good movement at the ankle-joint is retained. The technique has been previously described (Chapter XVII) and requires no further comment. The objections to the use of this method in all cases in which a bone operation is necessary for the correction of a club-foot deformity are obvious. If the patient is less than 10 years of age, bony fusion is uncertain and recurrence of the deformity is probable.

METATARSUS VARUS

Excessive adduction at the mid-tarsal region occurs almost invariably as a congenital deformity. In contrast with talipes equino varus the heel retains its normal alignment with the leg, while the deformity is situated entirely in front of the ankle Radiographically it is evident that the ossific centre of the scaphoid is small and appears later than normal, while the first metatarsal is often shorter than the 2nd or 3rd.

The disability caused by the deformity is slight, moulding of the foot in the young child prevents contraction of the soft tissues, while the wearing of an ordinary shoe tends to restore the normal alignment. Correction by operation is seldom necessary.

TALIPES CALCANEUS

Although this deformity is often congenital it may also follow on infantile paralysis, where the extensor muscles of the foot have recovered while the calf muscles have remained inactive. The probable explanation of the congenital type is the prolonged intra-uterine fixation of the foot in an acutely dorsiflexed position, with the dorsum of the foot lying along the front of the leg. As a result, the extensor muscles and the dorsal portion of the capsule of the ankle-joint have become contracted, while the calf muscles are weakened by overstretching

This is the most easily corrected of the congenital deformities of the foot, massage of the leg and stretching of the contracted extensor muscles being sufficient to restore the normal function and appearance.

RADIO-ULNAR SYNOSTOSIS

Fusion of the upper portions of the radius and ulna may be present over an area extending from one half to 3 inches. When present, the

forearm is fixed midway between pronation and supination; flexion and extension at the elbow-joint are free, but no passive or active rotary movements of the forearm are possible.

The radiograph (Fig. 160) indicates the extent of the bony fusion, which is present only in the proximal portion of the bones.

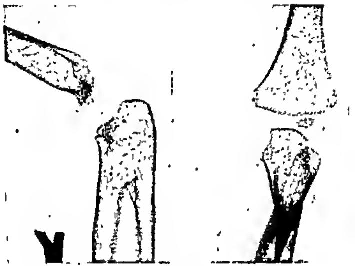


FIG. 160.—Congenital Radio-ulnar Synostosis.

Disability. In spite of the loss of rotation, the disability is comparatively slight, and the patient learns to compensate for the absence of rotary movements at the elbow by increased movements of the shoulder.

TREATMENT

The power of rotation of the forearm cannot be restored by any form of treatment. With extensive removal of the upper part of the shaft of the radius a small range of passive movements may result, but active rotation never follows this operation as the synostosis is accompanied by an absence of the rotator muscles. The patient should be advised to be content with the slight inconvenience and disability.

CERVICAL RIB

An abnormally large costal element arising from one or more of the lower cervical vertebræ is a comparatively common phenomenon, which, as a rule, gives rise to no signs or symptoms. Its presence is often discovered by chance during the course of a routine examination, although

occasionally a projecting bony mass may be present on one or both sides of the neck.

The abnormal rib arises from the 7th, and occasionally from the 6th cervical vertebra. It may be present as an enlargement of the costal element, extending up to, but not beyond, the tip of the transverse process. When larger it extends forward for a varying distance, ending in a cartilaginous tubercle or in a fibrous band which attaches the rudimentary rib to the 1st rib, or to its costal cartilage (*Fig. 161*).

Very occasionally a complete extra rib is present, ending in a costal

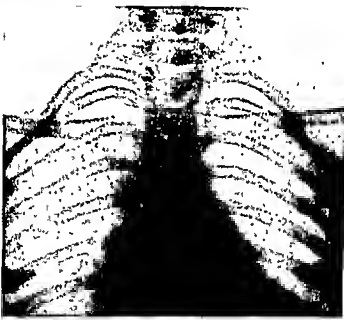


FIG. 161.—Buttress type of Cervical Rib

cartilage which articulates with the sternum or with the upper surface of the first costal cartilage. When large, the rib extends forwards between the two scalene muscles, the brachial plexus and the subclavian artery arching over it, the scalenus anticus muscle being usually attached to it in part. If the abnormal rib is complete, the space between it and the 1st rib is occupied by intercostal muscles similar to the arrangement between the other ribs, but when incomplete no muscular layer is present.

Mechanics

The possibility of symptoms being caused by the presence of the abnormal bony growth depends to some extent on the anatomical

arrangement of the brachial plexus. In some instances, the plexus receives a large branch from the 4th cervical nerve, a formation which is described as the prefixed plexus, whilst in others the branch from the 4th cervical nerve is rudimentary or absent, its place being taken by a large 1st dorsal element with a contribution from the 2nd dorsal nerve, the type described as the post-fixed plexus.

The development of abnormal ribs is seen more frequently when the plexus is of the pre-fixed type; in fact, the presence of a large nerve element in the lower cervical region obstructs the laying down of accessory bone, and may even lead to the underdevelopment of the 1st rib. In

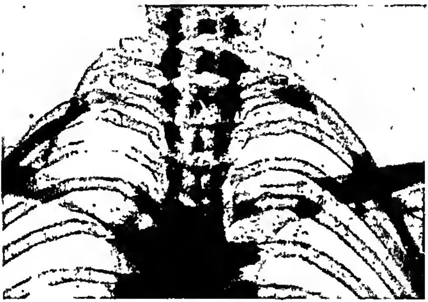


FIG. 162.—Complete Cervical Ribs causing no symptoms.

the normal course of development the shoulder descends, this alteration of position beginning usually at adolescence and continuing throughout life. This descent occurs in both sexes, but, owing to the difference in muscular development, the change occurs to a greater degree in females than in males. Following any severe strain, such as illness or childbirth, the resulting general muscular weakness permits a still greater drooping of the shoulder girdle, allowing the lower portion of the plexus to come in contact with the abnormal rib.

SYMPTOMS

Although cervical rib formations are found with equal frequency in males and females, symptoms attributable to their presence occur with

much greater frequency in women than in men, and although the bony abnormality is congenital in origin, complaints are not, as a rule, made before 25–30 years of age (Fig. 162).

The rôle of the scalenus anticus muscle in the production of symptoms attributed to the cervical rib has been demonstrated by Adson and Coffey, who showed that it is possible to produce paræsthesia over the distribution of the brachial plexus, and occasionally obliteration of the radial pulse, by making the patient elevate the chin, extend the neck, or rotate the head to the affected side whilst taking a deep inspiration. Adson attributes the pathological changes in the distal vessels to a disturbance of sympathetic innervation.

Sensory Symptoms. The most common complaint attributable to the presence of a cervical rib is tingling, and occasionally pain along the inner border of the arm and forearm. Relief can usually be obtained almost immediately by rest in the recumbent position. Shooting pains may be present after heavy work or after heavy lifting in which the arm has been forcibly extended. Cutaneous sensibility is, as a rule, somewhat diminished, although complete loss is seldom present. The area affected does not exactly correspond to the area of supply of any particular nerve or root segment.

Motor Symptoms. When present, these usually consist in wasting of the intrinsic muscles of the thenar eminence, the abductor and opponens muscles being affected, while the flexor brevis pollicis muscle remains normal. On rare occasions the loss of muscle power and atrophy are confined to the interossei and lumbrical groups. In either case, the muscular atrophy produces a progressive weakness of the hand and a peculiar clumsiness in carrying out the finer movements.

Circulatory Symptoms. The sub clavian artery, which lies, as a rule, in front of the cervical rib, may appear to be dilated, and the abnormal pulsation may suggest the presence of an aneurism, although aneurismal dilatation of the vessel does not occur.

Direct pressure on the sub-clavian artery by the abnormal bony mass or irritation of the vasomotor nerve fibres contained in the 8th cervical and 1st dorsal nerve roots frequently results in coldness and cyanosis of the hand and fingers. The radial pulse is often delayed and diminished in volume as compared with the other side, and ulceration and even gangrene of the ring and little fingers have been described. These vascular symptoms are probably the result of arteriospasm caused by the sympathetic irritation, and are seldom produced by direct pressure from the cervical rib.

Differential Diagnosis

Difficulty is frequently experienced in the differentiation of the muscle wasting and referred pains caused by the presence of a cervical rib from

similar symptoms and signs, which are found in syringomyelia, progressive muscular atrophy and ulnar paralysis.

In syringomyelia, the thenar eminence frequently remains unaffected for a considerable period, whilst in progressive muscular atrophy this group is usually the first to show a general wasting, which can easily be distinguished from the selective wasting caused by the presence of a cervical rib. The typical claw hand, with the wasting of the hypothenar eminence and intrinsic muscles, combined with the deformity of the fingers and loss of sensation over the inner border of the hand, which are the result of paralysis of the ulnar nerve, give rise to little difficulty in diagnosis.

Treatment

In the early stages, almost instant relief follows rest in bed by which the strain is relieved from the overstretched plexus. Mechanically, the wearing of shoulder braces helps to diminish the strain and reduce the severity of the symptoms. Exercises and massage of the cervical muscles tend to improve the position of the arms, and to prevent a return of symptoms.

In many instances operation alone can hold out any hope of cure.

Operation. A 5-inch incision is made along the posterior border of the sterno-mastoid muscle. In a short neck in which approach to the rib is comparatively difficult, further space may be obtained by another incision, 4 inches in length, extending from the lower end of the primary incision along the clavicle. Through this incision, the posterior triangle of the neck is exposed, the sterno-mastoid muscle retracted forward and the trapezius backward. The transversalis colli artery and vein which pass across the space are then divided and ligatured, and the plexus defined at the outer border of the scalenus anticus muscle. The brachial plexus is now retracted forward, care being taken of the lower trunk, which lies on the cervical rib, and especially of the branches of origin of the long thoracic nerve which pierce the scalenus medius muscle. With the retraction of the plexus the rib is now apparent, and is followed backward and divided close to its origin. In its separation the periosteum covering the rib should also be removed, so as to prevent the subsequent appearance of the bony bridge. When the rib is small, and is continued as a fibrous band, division of this band alone may be sufficient to relieve the symptoms.

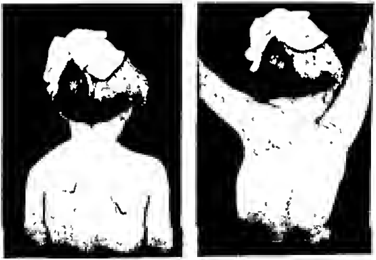
Division of the Scalenus Anticus. The relief of the symptom caused by a cervical rib is stated by Adson and Coffey to follow simple division of the scalenus anticus muscle at its insertion to the 1st rib. The operation is not difficult, the muscular insertion can be approached through a short vertical incision at the posterior margin of the sterno-mastoid. The phrenic nerve, which courses down on the scalenus anticus,

is defined and retracted, and the tendinous insertion of the muscle divided. This allows the upper ribs to fall, and relieves the plexus from pressure. In many instances the operation produces only a temporary relief of pressure, and the return of symptoms following the operation may necessitate the removal of the rib itself.

Operation on the 1st Rib. Occasionally, symptoms identical with those caused by a cervical rib result from the pressure of the inner border of the 1st rib on the 1st dorsal nerve. If resistant to conservative measures, relief of the symptoms can be procured by the removal of that portion of the 1st rib extending from the tip of the transverse process to the scalene tubercle. Into this portion of the rib is inserted the scalenus anticus muscle, which must first be divided before removing the bone; the operation can be carried out readily through the same incision as for the removal of a cervical rib.

SPRENGEL'S DEFORMITY

Sprengel's deformity, or congenital elevation of the scapula, results from an arrest of the normal development of the upper limb. Normally, this arises as a bud from the side of the cervical spine; at the end of the third month of intra-uterine life it is situated at the level of the upper border of the thoracic cavity. Normally the bud descends from this



(a) (b)

Fig. 163—Sprengel's Deformity.

(a) Showing elevation of scapula (b) Showing limitation of abduction of arm.

position and at full term it lies on the lateral aspect of the upper thoracic space. For some unexplained cause, in this deformity the descent has not taken place, and the scapula remains in an abnormally high position.

Signs

On examination the patient shows an abnormal prominence on one or both sides of the neck, especially noticeable when viewed from the front. The bony projection may extend for a varying distance above the clavicle and, in the extreme case, its upper border may be felt under the angle of the jaw.

As compared with the normal shoulder, the scapula on the affected side, in addition to being smaller in its vertical extent, lies at a higher level (Fig. 163). Its upper border lies closer to, and its inferior angle farther away from, the spinous processes of the adjacent vertebræ. The upper border is also hooked forward, and the lower border is tilted outwards from the thoracic wall, while the range of movement between the scapula and the thoracic wall is considerably diminished. On account of the tilting of the scapula, the shoulder movements are decreased, especially in abduction, which is limited to the horizontal plane.

Pathological Anatomy

There is usually a fibrous, cartilaginous or bony band extending between the upper and inner border of the scapula and the spinous

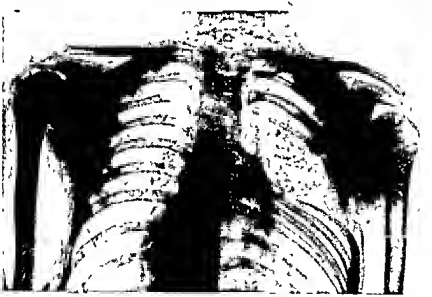


FIG. 164.—Radiograph of Sprengel's Deformity, showing also congenital deformities of ribs and wedge vertebræ.

processes of the 4th to the 7th cervical vertebræ. The muscles attached to the vertebral border of the scapula are diminished in size, fibrotic, and may be represented by a single layer of fibrous tissue. The body of the scapula is short, so that the transverse diameter is equal to, or greater than, the vertical. Other congenital bone defects, such as absence of ribs or muscles, or congenital abnormalities of vertebræ, are frequently discovered in the course of the examination (Fig. 164).

Treatment

As the condition consists not only in an alteration of the position of the scapula, but also in abnormalities of muscle and bony tissue, restoration to the normal position and to normal function is impossible. The object of treatment must be the improvement of function in the upper limb by increasing the mobility of the scapula on the chest-wall.

Stretching exercises, designed to increase the range of movement in the shoulder, lead to considerable improvement in the function of the arm, and should be continued for at least a year. By means of these exercises, the range of movement in the joint and in the shoulder girdle is considerably increased. The function of the arm improves steadily, and the permanent disability is usually a slight limitation of full abduction and external rotation, which causes *comparatively little trouble.*

Operation. If a bony bridge is present between the upper edge of the scapula and the spinous processes of the cervical vertebræ, removal of this bar by open operation may be of some slight advantage to the patient. Widespread division of tightened structures, and removal of fibrous bands, which would be necessary to produce free movements of the scapula on the chest-wall, are of no advantage, as the muscles which control the scapula are either absent or rudimentary.

MADELUNG'S DEFORMITY OF THE WRIST

A gradually increasing deformity of the wrist-joint, which usually appears in late childhood or early adolescence. The lower portion of the shaft of the radius gradually bends forward, leaving the lower end of the ulna and its styloid process as an obvious projection on the dorsum of the wrist (*Fig. 165*). As a result of the displacement, dorsiflexion of the wrist is diminished or lost, and with extreme deformity, pronation and supination are also impossible. The strength of the hand and fingers is only slightly diminished, and the patient can perform almost any form of heavy work.

Etiology

Nothing is known as to the cause of the deformity, except that there is distinct ligamentous laxity, and it is possible that there is also some persisting rachitic weakness of the affected bone.

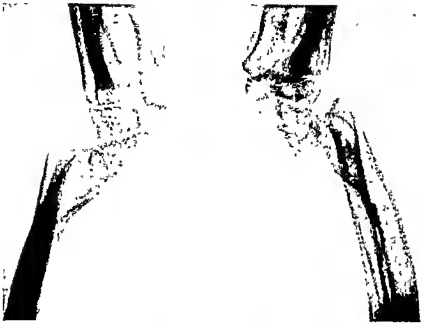


FIG. 165.—Madelung's Deformity.

TREATMENT

Progress of the deformity may be checked by rest and relief from heavy manual work. Massage of the forearm strengthens the muscle control of the wrist, and the wearing of a leather case may help to some extent in improving the use of the hand.

Operative interference is only necessary when improvement of the appearance of the hand is desired. An oblique osteotomy of the radius, with alteration in the alignment, usually results in improvement in the appearance, but not in any increase of strength.

CLUB HAND

Almost any type of congenital deformity may be present in the wrist and hand, their occurrence depending on the absence of one or more of the bones of the forearm, wrist or hand. The deformity which is seen most frequently is the club hand, which follows on congenital absence of the radius. The hand, in which the thumb may be missing, is placed at right angles to the lower end of the shaft of the ulna. This deformity is frequently hereditary, several instances being known of transmission through two generations.

At first, the child has little power of control over the fingers, but

gradually strength is developed and the displaced hand becomes extremely useful. Various operations have been devised for the correction of the deformity; thus, the lower end of the ulna may be split vertically, one portion being driven to the outer aspect of the carpus to replace the radius, or a bony strut may be inserted between the outer side of the carpus and the shaft of the ulna, in an attempt to balance the action of the wrist-joint.

The result of this type of operation is usually unsatisfactory, the usefulness of the hand being diminished following the operation, and greater improvement can be obtained by stretching the fingers, massage, and encouragement of the patient.

CHAPTER XXIII

RICKETS

A constitutional disease of infancy, which, although primarily associated with the dietitian and the physician, is at a later stage of considerable interest to the surgeon, on account of the numerous deformities which may develop as a result of the yielding of softened bones.

Etiology

The disease results directly from defective assimilation, and follows most commonly on the replacement of breast by artificial feeding. Instances of the development of rickets while the child is still being breast-fed are not uncommon, and are attributable to prolonged lactation, or a deficiency in the mother's milk. Experimentally, the disease can be produced in animals when they are subjected to conditions involving absence of exercise and sunlight, with a diet deficient in various contents, of which the most important are Vitamin D, calcium and phosphorus. The disease usually appears in the first 9 months of life, when the tissue changes are at their maximum, but a condition apparently identical with infantile rickets is occasionally seen in later childhood or in adolescence, and has been given the name "Delayed or Adolescent Rickets." In many instances this will be found to be a recrudescence of the infantile form, although in some, no history or indication of a previous rachitic affection can be found, and the disease then is probably the result of overstrain of tissues which are undergoing abnormally active alterations.

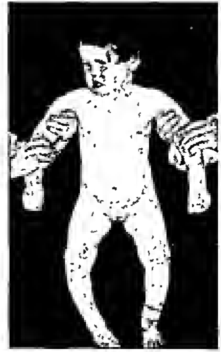


Fig. 166.—Rachitic child, showing enlarged forehead, prominent abdomen and deformities of the lower limbs.

Signs and Symptoms

In the more severe degrees of rickets the clinical signs are so apparent and so definite that the diagnosis can usually be made with certainty (Fig. 166).

1. The forehead is abnormally broad and prominent.
2. The chest is compressed laterally and the sternum is prominent (Pigeon Chest).
3. The abdomen is prominent with a deep sulcus between it and the thorax (Harrison's Sulcus).
4. The thighs are deformed in many directions.
5. The epiphyseal areas are all enlarged.
6. The bony palate is more highly arched than normal.

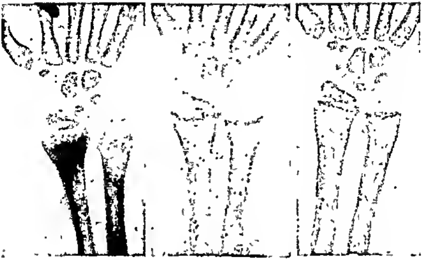
In addition to changes in the osseous framework there are other general changes, which, like the bony deformities, vary with the severity of the disease. In a mild case the outstanding features are increased perspiration, delayed dentition, and impaired circulation, with weakness in the *voluntary and involuntary* musculature. As a result, bronchitis, restlessness, irritation and catarrh of the mucous membranes are prominent features. In the more severe type the child is unable to stand or walk on account of excessive tenderness in the bony framework; in fact, this loss of power is occasionally so complete that it may suggest the diagnosis of infantile paralysis (the pseudo-paralysis of rickets). The greatest and most characteristic alterations, however, occur in the bones and in their surrounding membranes.

Pathological Changes in the Bones

1. The medullary cavity is greatly increased in size.
2. The periosteum is thickened, infiltrated, spongy and adherent.
3. The epiphyseal cartilage, which is normally thin and bluish, is thickened, swollen and cloudy in appearance.
4. The epiphyseal junctions are enlarged, and the shafts of the bones are thickened by the deposit, chiefly on their concave aspects, of subperiosteal bone.
5. With healing of the disease these changes subside rapidly, leaving the bones abnormally hard.
6. In certain acute cases the bone is brittle and liable to fracture.

Radiographic Changes

These are usually of great assistance in arriving at the diagnosis. In *the early stages of the disease there is* a general loss of definition of bone structure—the shaft of the long bones appearing somewhat decalcified and slightly fuzzy. This change is even more obvious in the epiphyses, which are cloudy and badly defined; later, the ends of the diaphyses become irregular and splayed out, with some sub-periosteal bone deposit. The want of definition in the epiphysis and the end of the diaphysis persists until healing takes place, when the outlines again become sharply defined with increased calcium deposit, and improved definition in both epiphysis and diaphysis (Fig. 167 *a*, *b* and *c*).



(a) Active (b) Becoming quiescent. (c) Cured.

FIG. 167.—Radiograph of Rickets.

DIFFERENTIAL DIAGNOSIS

In a severe case, in which the general deformities and the typical radiographic changes are present, little difficulty is experienced in diagnosis, but occasionally, when the signs are ill-defined, some difficulty may be encountered in differentiating the condition from:

1. **Fragilitas Ossium.** There is a similarity between this condition end the acute stage of rickets; in both there is a tendency towards the production of multiple fractures, which cause weakness and deformities of the limbs. The diagnosis can usually be made largely on the radiographic appearances, which demonstrate the absence of rickety changes at the epiphyseal lines, and the generalized thinning of the bone cortex. which is characteristic of fragilitas ossium.

2. **Syphilitic Epiphysitis,** which is characterized by acute tenderness and swelling of a joint, the affection being, as a rule, bilateral. The diagnosis here is made on the discovery of a positive Wassermann reaction, and on the radiographic appearances of the affected joint. Unlike the ill-defined " fuzzy " appearance of the rachitic bone, a partial or complete displacement of the epiphysis on the diaphysis is usually present.

3. **Scurvy,** which gives sub-periosteal hæmorrhages with swelling, extending from the epiphyseal plate, along the shafts of the bones, and also by signs of hæmorrhage in other areas, especially the submucous and subcutaneous tissues (Fig. 168).

FIG. 168.—Radiograph of Scurvy.

4. Renal Rickets or Renal Dwarfism. This clinical entity of chronic nephritis, associated with severe bone changes and deformities, has many of the characteristic appearances associated with later or adolescent rickets. The disease usually becomes obvious between 5 and 12 years of age. The child is stunted in height, and deformities of the lower limbs appear rapidly, the most common being an obvious genu valgum deformity of both legs. The disease of the kidney is recognized by polyuria, the urine passed varying between 1200 and 3000 c.c., of a low specific gravity, accompanied by a distinctly high blood urea concentration. The radiographic appearance of the epiphyseal areas is of considerable diagnostic value, as it shows normal epiphyses in a cup-shaped, dilated, diaphyseal end, in which there is little or no decalcification (Fig. 169)

In the treatment of renal rickets operative correction of any deformity must be avoided on account of the grave risks involved in the administration of any type of anæsthetic The deformities can usually be controlled, and often corrected by the use of irons, to which the deformed limbs can be moulded.

FIG. 169.—Radiograph of Renal Rickets

TREATMENT OF RICKETS

The prevention of the disease is usually a comparatively simple problem; although milk, either human or bovine, is the ideal form of food, in some cases it does not contain sufficient vitamin D, and must be supplemented by some other food, such as cod-liver oil, which is rich in this essential. Open air and sunlight are almost as important as the type of food in preventing the disease. When sunlight is not available, artificial sunlight, given under strict

control, is of great benefit owing to its action in producing vitamin D from the skin.

The aim of surgical treatment in acute rickets is the prevention of deformity and the correction by moulding of any existing deformity while the bones are still soft. Recumbency during the acute stage of the disease is essential, in order that the common deformities of the legs, hips and spine may be prevented. When a knock-knee or bow-leg deformity has already developed, improvement in the alignment follows corrective splinting of the legs at night. When the disease is cured and deformities remain, their correction should be considered not only because of their appearance, but even more with the object of preventing secondary deformities which arise at a later date.

Deformities

The deformities of rickets are simply exaggerations of the normal curves in the long bones of the body, the softened bones of the lower limbs yielding to the continuous strain of weight-bearing. In the chest and upper limbs the alterations in the bones result from the continued action of the attached muscles, which produce either a change in alignment of the softened bones or the development of bony outgrowths at the point of muscular attachment, or an outgrowth of bone at the point of insertion.

The more common deformities are described under the following headings:

RICKETY KYPHOSIS

A condition of exaggerated antero-posterior curve of the spine is present in most cases of advanced rickety deformity. This type of kyphosis has certain characteristics. Thus, it is invariably present at the dorso-lumbar angle, and its curve is more acute than most other forms of simple kyphosis. For this reason it may occasionally be mistaken for tuberculous arthritis with deformity, but the absence of rigidity and the disappearance of the kyphos on recumbency should clear up any doubt in regard to the diagnosis. No special treatment is necessary for its correction, as the deformity usually disappears as the general condition improves.

COXA VARA

An alteration in the angle at which the neck of the femur is attached to the shaft is present more frequently than any other deformity in rickets. Normally, in a child, the neck of the femur is set on the shaft at an angle of 130 degrees or more. Any considerable decrease of this angle, arising from any cause, is described as coxa vara, which in its

extreme forms gives rise to the waddling gait and widespread hips so characteristic of rickety children.

Symptoms and Signs

There are, as a rule, no symptoms attributable solely to the deformity, although the child may occasionally complain of aching over the hips and down the thighs after prolonged exercise. The signs are obvious, and consist of apparent broadening of the pelvis, due to raising and spreading of the trochanters, with limitation of abduction at the hip to a degree depending on the severity of the displacement. As the deformity is, almost invariably, bilateral, there is, as a rule, *no difference in the length of the limbs.*

Radiographic Appearances

In the radiograph the alteration in the angle can be recognized and measured and, in addition, in the acute stages of the disease the usual rachitic decalcification and fuzziness of the epiphysis and diaphysis can be seen.

Treatment of Coxa Vara

When the disease is still active, relief from body-weight and general antirachitic treatment are usually sufficient to restore the normal alignment of the bone. When the disease has been cured and the deformity remains, surgical interference may be necessary, either because of persistent aching, or on account of the waddling gait. Surgical interference, if considered necessary, is carried out on the lines indicated in Chapter XII.

BOW LEGS OR GENU VARUM

Any exaggeration of the normal outward curve of the leg from the knee to the ankle is described as bow legs; occasionally, instead of an outward bowing of the leg the tibia is curved forward, giving rise to the condition known as anterior bow leg. There is usually little difficulty in regard to the diagnosis of the cause of either of these curves, other signs of rickets being present.

Some difficulty may occasionally be experienced in differentiating the anterior rickets curve from the acute anterior curving of the tibia (sabre tibia), which is so characteristic of congenital syphilis. The differentiation is made on the discovery of other signs of syphilitic infection, and on the presence of a positive Wassermann reaction. It is possible also to distinguish between the two conditions from an examination of the tibia alone. Thus, in congenital syphilis the curve is produced by the laying down of large subperiosteal masses of bone on the convex aspect of the bone, as compared with the deposit of bone on the concave side, which occurs in the rickety deformity.

Treatment

As a rule, no surgical treatment is required, the bow-leg deformity usually disappearing in response to appropriate diet and use of the limb. If, after 12 months, an obvious deformity is still present, correction should be considered.

When the disease is still active the soft bone can be moulded and corrected by bandaging the leg to a straight splint. Combined with the moulding antirachitic treatment must be continued. After healing of the disease, correction of any remaining deformity is possible only by osteoclasis or osteotomy.

Correction by Osteoclasis. The operation of osteoclasis, or straightening of the leg after the production of a subperiosteal fracture,

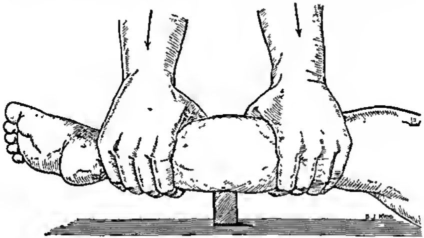


Fig. 170.—Osteoclasis showing hands protecting epiphyses of the Tibia.

is rarely employed in present-day surgery. When used, the fracture is produced at the apex of the deformity by a special instrument, the osteoclast, or by the use of a wedge of wood (Fig. 170). This method is preferable to the use of any form of osteoclast, as the soft tissues are less severely damaged. In the correction, the fibula is completely broken, while the tibia shows at most a greenstick fracture. After straightening, the leg is fixed in a plaster case for at least 6–8 weeks, the foot being maintained in line with the leg to prevent external rotation. After-treatment consists in massage and exercises, no form of splinting being necessary if the ligaments of the knee are not excessively lax.

Correction by Osteotomy. Occasionally, on account of the hardness of the bones, correction by osteoclasis is impossible, and osteotomy at the same level can be performed with safety. The decision as to the

necessity of performing osteoclasis or osteotomy does not depend on the age of the patient, but on the hardness of the bones. Thus, osteoclasis may, in some children, be possible up to the age of 5 or 6 years, whilst in others, osteotomy may be necessary in a child of 3 or 4 years.

For bow leg, the osteotomy should be a simple transverse division of the bone at the point chosen, whilst in the correction of the anterior bow

FIG 171 —Wedge Osteotomy for anterior bowing of the Tibia.

leg the removal of an oblique wedge, as in Fig. 171, is the most efficient method of correcting the deformity, and at the same time assuring subsequent union of the fracture. After either procedure, the fixation and correction must be maintained until union is complete.

KNOCK-KNEE OR GENU VALGUM

This very common deformity begins, as a rule, in early childhood following on rickets. With normal children in the erect position, the internal femoral condyles and the internal malleoli are closely approximated. In this position the weight of the body passes more or less equally through the femoral condyles, but, if the leg is abducted, as in knock-knee, body-weight is borne almost entirely on the external condyle of the femur and the external tuberosity of the tibia. The internal condyle of the femur and the internal tuberosity of the tibia, which are thereby relieved from pressure, enlarge on the inner side of the joint and form a prominence, which gradually develops with the increasing abduction of the leg.

As a rule, deformity is due to this overgrowth of the inner side of the femur, the alignment and shape of the tibia remaining normal. Occasionally, enlargement and elongation of the inner side of the tibia is alone responsible, while in some cases both bones take part in the deformity.

TREATMENT

Conservative. In many instances a young patient suffering from slight knock-knee is brought to the surgeon by parents who complain that the child walks with inturned toes. They have usually tried to alter this so-called deformity by sending the child to a dancing class, where instruc-

tion is given in turning the toes outwards. This turning in of the toes, in the presence of a knock-knee, should not be corrected but rather encouraged by raising the heel of the shoe on the inner side. By walking in this manner the child is endeavouring to correct the deformity and carry the weight of the body on both condyles of the femur. When the alignment of the knee has been corrected the inturning of the toes disappears.

Moulding. As with all rickety deformities, continued moulding is often successful in correcting the knock-knee in the acute stages of the disease, and, in a large proportion of children so treated, operative correction is unnecessary. If, after moulding, the remaining deformity is slight, a knock-knee iron should be used to maintain and complete the correction. The iron should be removed only when correction has been obtained, or when it is obvious that further improvement is impossible.

Osteotomy. The decision as to the advisability of performing a corrective osteotomy should be based on the condition of the bones, and not on the age of the patient. Thus, it may be possible to correct by

FIG. 172.—Jones' Osteotomy Saw.

moulding the deformed leg of one child of 8 or 9 years, whilst in another an osteotomy may be necessary at 3 or 4 years of age. The site of the osteotomy depends on the amount of deformity present above and below the knee.

In a child, even when the deformity is partly tibial in origin, complete correction can usually be obtained by osteotomy of the femur. The bone is divided sub-periosteally at a point one inch above the adductor tubercle from the outer aspect of the thigh by a saw (Fig. 172). After cutting through five-sixths of its substance, the remaining portion is fractured by adducting the leg against resistance at the inner side of the knee-joint. Fixation and correction after the osteotomy are obtained by the use of a Thomas splint with extension and a supporting back splint. By the use of two straps the deformity is over-corrected, the condyles of the femur being pulled to the outer bar of the splint, whilst the ankle is drawn to the inner bar. Fixation is continued for 8 weeks when consolidation has usually occurred. Non-weight-bearing exercises can then

be given, and free use of the limb allowed after a further 2 weeks, a splint being used for a time if ligamentous laxity of the knee is obvious. The femur may also be divided from the inner side of the thigh by an osteotome, the bone being divided three-quarters of an inch above and in front of the adductor tubercle. The after-treatment is identical with that already described.

When the deformity is present in the adult, correction by tibial osteotomy is generally more satisfactory than by division of the femur. This preference for a lower level of correction in the adult is based on a recognition of the adaptive changes which take place in the soft tissues and bones of the knee-joint, as the result of long-continued weight-bearing in the deformed position. As a result of strain, the internal lateral ligament is already stretched and thickened, and the cartilage covering the condyles of the femur and the tuberosities of the tibia shows adaptive arthritic changes. If the alignment of the joint is altered by osteotomy of the femur strain is thrown on cartilaginous surfaces which have previously borne no weight, and the correction is followed by a long period of comparative disability, which may be avoided by alteration of the alignment of the limb below rather than above the knee.

In performing this tibial osteotomy a very small wedge, with the base inwards and the apex towards the fibula, is removed from the tibia, about 2 inches below the joint level. Even with considerable deformity the wedge must be very small, or over-correction results. When the wedge is removed the gap is closed by adducting the leg, which is retained in the corrected position in a plaster case for 8 weeks, full movements being rapidly restored by exercises and massage. As a rule, no support is necessary, but, if the knee-joint is abnormally mobile, a knock-knee splint should be used until the lateral laxity has disappeared.

CHAPTER XXIV

GENERAL AFFECTIONS OF BONE

OSTEITIS DEFORMANS, PAGET'S DISEASE

A disease, which is undoubtedly more common than is generally realized, characterized by thickening and softening of all the bones, and rarely seen in patients before middle life. Nothing is known as to its cause, no indication of bacterial infection or endocrine disturbance being present, and there would appear to be no relation between the onset of the disease and injury.

SYMPTOMS AND SIGNS

As a rule, the patient first complains of aching and tiredness in the legs. Owing to the softening of the bones, alterations in the shape of the limbs gradually appear, the first and most obvious change occurring in

FIG. 173.—Anterior bowing of the Tibia in Paget's Disease

the tibia, which is bowed forward (Fig. 173) with a thickened and bossy surface. Similar alterations may occur in the thigh or in the arm or forearm bones, and an increasing kyphos leads to a gradual diminution in the patient's height. The skull bones take part in the change, the

head and forehead becoming enlarged, whilst the bones of the face retain their normal size. Owing to the softening, fractures of any of the long bones may occur from comparatively slight injury. Union of these fractures is usually satisfactory, the line of fracture uniting firmly, but at a somewhat slower rate than normal.

Pathology

The disease, which may remain localized to one bone, or may be present in every part of the skeleton, produces a general thickening and irregularity of the surface of the affected bones The medullary cavity is diminished by the encroachment of a mass of newly formed vascular fibrous tissue, whilst new bone is formed under the periosteum. The internal structure of the cortical bone is considerably modified, the lamellæ are irregular, small isolated nodules of eburnated bone are present, together with *cystic cavities containing a yellowish gelatinous material.* The cortical bone is also partly replaced by fibrous tissue, which is also present in the medulla where it replaces the bone forming elements. At a later stage of the disease the strength of the bone is secured by the development of lamellæ of new bone in this new fibrous tissue.

Fig 174.—Paget's Disease affecting the Tibia, showing transverse striation on the apex of the convexity.

Radiographic Appearances

The radiographic appearances are very characteristic with the thickened "bossy" cortex, the narrowing of the medullary canal, the peculiar patchy appearance of the bone structure, and the definite increase of the normal curves of the affected bones (Fig. 174). Horizontal lines are frequently present on the convex aspect of the bone, extending for a varying distance into its substance at right angles to its long axis. When a fracture occurs, its line usually passes through one of these markings (Fig 175), the characteristic feature of these fractures being the clean-cut division of the bone in a straight line across its length. Although occurring in bone which is so obviously abnormal and in which fibrous tissue is abundant, these fractures unite readily, the callus of union of the fracture being normal

bony tissue which shows no sign of the pathological changes present in the fractured bone.

The skull shows considerable thickening of the bones of the calvarium, the surface being very irregular and "knobby," giving the characteristic

Fig. 175.—Fracture of Femur affected by Paget's Disease.

"smoky" appearance (Fig. 176). Calcareous degeneration of the arteries can also often be observed at various points.

Differential Diagnosis

Syphilitic Osteitis. The appearances present in syphilitic bone infection resemble closely those of Paget's disease and a differentiation

may be extremely difficult. **In its typical form the bone affected by syphilitic osteitis is not so irregular as that of Paget's disease, which has more of a cottonwool appearance (Fig. 177*a* and 177*b*).** Frequently the diagnosis rests on the results of the Wassermann and Kahn tests.

Osteitis Fibrosa. This condition may, in its early stage, present a radiographic appearance very similar to that of the early stage of osteitis deformans. The points of difference are, the presence in osteitis fibrosa

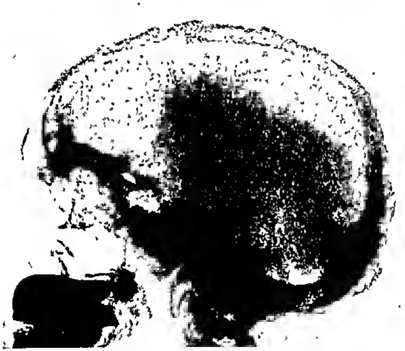


FIG. 176.—Paget's Disease of the Skull

of larger cystic cavities in the affected bones, and the absence of involvement of the skull bones.

Acromegaly produces a general enlargement of the skeleton, with a great increase in the size of the bones of the face, and with a definite enlargement of the cella turcica, as shown in the radiograph.

Prognosis

Unfortunately nothing can be done to arrest the course of the disease. Occasionally, the condition of the patient remains stationary for a time, and undeserved credit may be given to the treatment which is under trial

at the moment. As the deformities increase, the activity of the patient diminishes and the general health suffers. As a rule, death does not take

(a) (b)

Fig. 177a.—Syphilitic Osteitis affecting the Tibia.
Fig. 177b.—The same 4 months later.

place for many years, and then usually owing to some chest complication, or occasionally to the development of sarcomatous changes in one of the affected bones.

Treatment

Treatment consists of:

1. Supporting the weakened bones by splintage.
2. Relieving the boring pain, which is so frequently present in the affected bones.

Splintage. When the leg has become bent and unable to bear the patient's weight, relief can be obtained by the use of a caliper splint, which takes weight directly from the tuberosity of the ischium, thus relieving the leg and preventing any increase in the deformity. Similarly, the deforming spine can be supported by the use of a posterior support, which enables the patient to stand upright, and permits freedom of breathing.

Relief of Pain. The patient may complain of a continuous dull, boring pain in one of the affected bones, most commonly the tibia. This pain is not relieved by rest, elevation of the limb, or any external applications, and is frequently worse at night. It may, however, be relieved by a linear osteotomy of the bone in the area of the greatest tenderness. An incision is made in the bone through the substance of the cortex into the medulla. This procedure is, as a rule, beneficial, and results in a diminution of pain, although not in its complete disappearance.

ACHONDROPLASIA

Achondroplasia, which in many respects closely resembles rickets, was at one time considered to be an intra-uterine manifestation of this disease, but further investigation has proved it to be due to a disturbance of the normal growth of the cartilage forming the epiphyseal plates, the growth *in length of the long bones being interrupted, whilst the sub*periosteal bony deposit proceeds in a normal manner. The interruption of the normal cartilaginous growth consists either in a softening of the cartilage cells, with diminution of their growth, or in their widespread proliferation with irregular ossification. The first signs of the disease appear early in intra-uterine life, but no reasonable explanation of its occurrence has yet been advanced.

Symptoms and Signs

The child's body continues to grow normally, whilst the limbs remain short and show obvious enlargement in the region of the epiphyses. The head appears large, *the intelligence remains normal, while the bridge of* the nose is usually depressed and may be distinctly flattened. The hands, which are short and thick, show a very characteristic deformity of the fingers. The index, ring and little fingers do not, as is normal, lie parallel with the middle fingers, but point outwards like the spokes of a wheel.

In the lower limbs extreme bowing of the tibiæ is common, and because of this the feet are everted and appear flat without any sign of arching.

Radiographic Appearances

The characteristic radiographic appearances of achondroplasia are the shortening and thickening of the long bones, combined with early ossification of the epiphyses.

The disease is to be differentiated from rickets by the irregular ossification and enlarged epiphyseal lines, which are characteristic of rickets, as compared with the clearly cut line and early ossification of the epiphyseal plates (Fig. 178), which is present in achondroplasia.

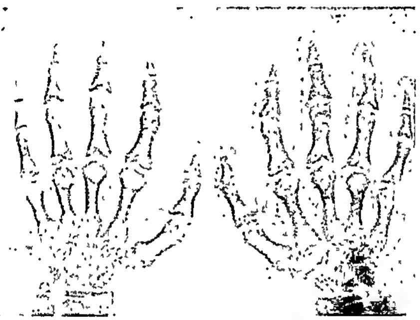


FIG. 178.—Radiograph of Achondroplasia

TREATMENT

No general treatment of any value has yet been suggested, but occasionally the bowing of one or both legs may be so extreme that correction by osteotomy may be used to prevent secondary deformities of the feet.

OSTEOGENESIS IMPERFECTA OR FRAGILITAS OSSIUM

This condition is recognized clinically by the frequent occurrence of fracture. This tendency may be present at birth, or may, in the more usual type, make its appearance during childhood. Nothing is known

as to the cause of the condition although, in many instances, there is a distinct familial tendency, the disease being *present in several or all* of the children in one family.

Clinical Features

Fracture of one or more bones may be present at birth, but, as a rule, the tendency to fracture appears about the fourth or fifth year of life. The fractures themselves are usually the result of some very slight trauma, such as twist of the leg or arm. They have even been known to occur in a limb which was already adequately protected by splintage. The fractured bones show little tendency towards displacement, and after fixation become firmly united, although the process of consolidation is slower than normal.

The child is usually thin, with poor muscular development, and, as a rule, shows a peculiar china-blue coloration of the sclerotics. Frequently, the mother also shows this blue tinge of the eyeball, although she may never have shown any tendency towards abnormal brittleness of the bones.

Radiographic Appearances

As the bones are peculiarly thin, and have a poor calcium content, the shadow cast on the radiograph is very similar to that of osteomalacia, although in fragilitas ossium there is not the tendency to bending of the long bones which is so characteristic of that disease.

Pathology

The fibrous layer of the periosteum is thickened, with its deeper layer of bone-forming cells more spindle-shaped than normal. The bone cells are large and oval and show little tendency towards the formation of Haversian canals. The cells present on the outer side of the cortex show no definite arrangement, and remain as flat laminated plates.

Prognosis

If the child lives through the period of adolescence the tendency to fracture diminishes and may disappear. Frequently, however, death follows some intercurrent disease before the age of 18 years.

Differential Diagnosis

Acute Rickets. In the acute or florid stage of rickets multiple fractures are comparatively common, and their occurrence may suggest the diagnosis of fragilitas ossium, but in rickets the epiphyseal line is enlarged, irregular, and the radiograph shows irregularity of the end of the diaphyses and of the epiphyses, a condition which is never present in fragilitas ossium.

Osteomalacia. Although usually a disease of adult life, osteomalacia may occasionally be present in young children. In osteomalacia the bones become thin and weak, owing to a process of absorption of lime from a structure which was at first normal, whilst in fragilitas ossium the bone was abnormal from the first, and does not at any stage show the bowing which is the outstanding feature of osteomalacia.

Treatment

No special form of medication seems to have any effect on the course of the disease. The fractures are treated in the normal way, and, if fixation is continued for a sufficiently long period, union usually becomes complete. Protection from strain on a limb which has broken on many occasions is often advisable, and may be required for several years. Medical treatment, by the administration of calcium salts in various combinations, has not been successful in increasing the bone density, or in preventing the tendency towards fracture.

MARBLE BONES OR ALBERS-SCHÖNBERG DISEASE

This condition of increased density of some, or very occasionally of all the bones of the body, is caused by an excessive deposit of lime salts in the bony tissue. In the affected bones the cortex is greatly thickened, while the medullary canal is diminished in size. Owing to the increased thickening of the cortex the Haversian canals are also constricted, leading in some instances to painful pressure and complaint of pain. Radiographs show the affected bones to be much darker than normal (Fig. 179).

Little is known in regard to the cause of the condition, although recently it has been demonstrated that bone changes of a similar type frequently occur in conjunction with anæmia.

OSTEITIS FIBROSA CYSTICA

Von Recklinghausen first described the condition, which is characterized by the development in bone of fibrous tissues and single or multiple cysts. From a clinical point of view the disease can be divided into two groups:

1. Generalized Type.
2. Localized Type.

Generalized Type

Instances of widespread bone involvement are found invariably in young adults, women being affected more frequently than men. The

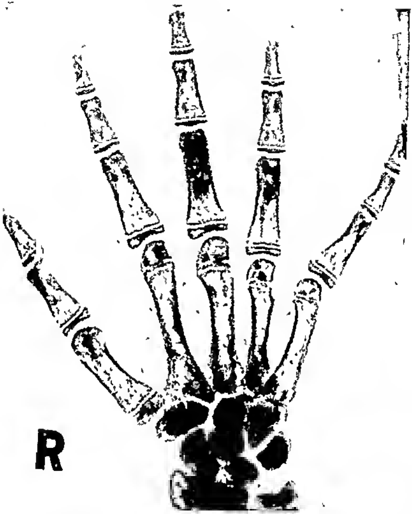


FIG 179.—Radiograph of Albers-Schönberg disease showing typical 'candle dripping' effect

onset of the disease is usually characterized by complaints of pain and aching in the affected areas, which may be entirely separate from each other. Attention may first be attracted to the condition by the occurrence of a fracture through the site of disease. These fractures usually follow a comparatively slight injury, and are not accompanied by the usual amount of pain, or by the crepitus which is invariably present when a healthy bone is broken.

Radiographic Appearances

The bones cast a shadow of diminisbed density, and show cystic areas of varying extent. Round these cavities a ring of sclerosis is often discernible; signs of old or recent fracture may be present, while the cortex of tbe bone is usually not expanded at any point. When the whole bony skeleton is examined, similar chaoges may be discovered in several of the other bones wbich have given no sigo of abnormality.

Pathology

Hunter's work has shown that generalized osteitis fibrosa is frequently associated with a hypercalcæmia, combined with a low phosphorous content in the blood serum, and with a tumour of one of the parathyroid glands. This tumour is simply an enlargement and overgrowth of the normal parathyroid tissue, which by its activity produces an increased secretion of parathormone, which acts directly on calcium metabolism. The calcium content of the blood may be increased to 11–13 mgm. per 100 c.c., tbe calcium cooteot of the urine may be three times tbe normal, whilst that in the fæces remains within the oormal limits.

In the area of disease tbe bone is partly replaced by vascular connective tissue, wbich later becomes converted into fully formed fibrous tissue. In this connective aod fibrous tissue mass hæmorrhages occur readily, aod by degeneration cavities are formed. These spaces are lined by fibrous tissue containing widely scattered giaot cells whicb, it has been suggested, may be osteoclasts. Owing to the absorption of lime salts the affected bones have a moth-eateo appearance, and, oo section, bone absorption and new bone formation are seeo occurring side by side. The new bone, which is largely composed of osteoid tissue with a low calcium content, has little rigidity.

Treatment

When several bones are affected and tbe calcium content of the blood is definitely increased, the paratbyroid tumour, wbich is the cause of the condition, should be looked for and removed. This operation is not always a simple one, as tbe tumour may be present behind tbe sternum, or in some other abnormal position, and its removal may oecessitate a very extensive and severe operation involving, in some instances, division of the sternum.

If a tumour is found and removed, a gradual improvement may be expected in the structure of the affected booe. This improvement may be judged by several radiographs in which can be seen a gradual diminution and eventual disappearance of tbe cystic spaces, while the wbole cortex becomes denser and more normal in appearance. When this stage has been reached serious deformity, which has developed as a result of bone softening, or of tbe intercurrent fracture, may be dealt with by

osteotomy or moulding, union after the osteotomy occurring at the *normal rate.*

Localized Type

Localized bone changes, indistinguishable from those of the generalized type, may be present for many years without the development of the calcium changes, and, as a rule, without any parathyroid tumour.

FIG 180.—Localized Fibro-cystic Disease, showing the fracture just below the head of the radius.

Clinical History

Aching pain in the affected area is the usual indication of the presence of the disease. Occasionally, fracture through the site of the disease may be the first indication of the abnormality (Fig. 180)

Pathology

The pathological changes are usually identical with those seen in the generalized type of the disease, the only difference being a considerable enlargement of one of the cystic cavities. This is usually lined by fibrous tissue surrounded by a thin layer of sclerosed bone. The contents of the cyst are reddish-brown, vascular, connective tissue, whilst the bone external to the sclerotic rim shows the same alterations as those of generalized osteitis fibrosa.

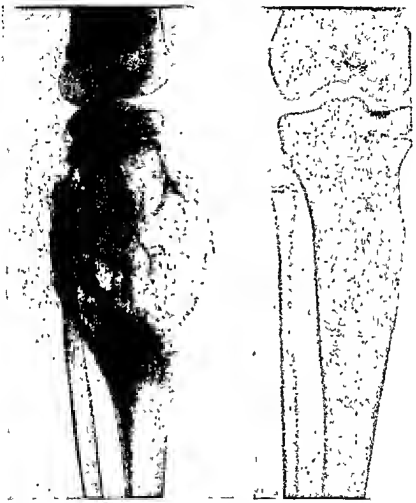
Radiographic Appearance

The bone surrounding the cystic cavity is usually thinned out and expanded to form a shell, which may project for a short distance into the neighbouring healthy bone (Fig. 181 *a* and *b*), from which it is clearly differentiated by the localizing sclerosis.

Treatment

Occasionally complete disappearance of the disease follows the healing of a fracture which has occurred through a cyst. As a rule, however, although healing may take place at the fracture level, the disease continues to progress either upwards or downwards, a complication which necessitates an operation for clearing out the disease by curettage of the lining

wall of the cyst. After removal of the contents and the lining membrane, the cavity may be filled by a bone graft or numerous bone chips. These not only fill the large space, but act also by stimulating bone formation



(a) (b)

FIG. 181—Single Multilocular Cyst, upper end of tibia
(a) Before operation (b) 18 months after area had been scraped out.

from the freshened surfaces. The implantation of bone is not essential, as healing can occur following the curettage, but, as a rule, closure of the cavity is more rapid when this method is used. If it is thought inadvisable to complicate the operation by removing bone to fill the cavity, new bone

formation may be stimulated by crushing in the walls of the cyst, thus partially obliterating the cavity.

RENAL DWARFISM OR RENAL RICKETS

The association of pathological changes in the kidneys, with diminished growth, and with deformities closely resembling those of rickets, has only been recognized during the past 30 years.

CLINICAL HISTORY

After an apparently normal childhood the patient—at the age of 8–12 years—in the course of a few months develops a severe deformity of knock-knee or bow leg. The child is much below the normal size and weight, being usually 6–8 inches less in height, and 1–2 stone lighter than the average child of the same age. The urine is abundant and of low specific gravity; dye and concentration tests show that the renal efficiency is lowered, while the percentage of blood urea is considerably raised, being from 100 to 250 mgm. per cent. *On inquiry it is found that* for a long time the child has suffered from excessive thirst, of which no particular notice has been taken.

Radiographic Appearances

The radiographic appearances of the affected bones are quite distinct from those of ordinary rickets The epiphyses, unlike those in the rickety child, appear to be normal in structure and in shape, being regular and clearly defined, the ends of the diaphyses are spread out and cup-shaped, while the space between the normal epiphysis and the widened diaphysis is considerably increased (Fig 169)

PROGNOSIS

The disease is almost invariably fatal, death usually occurring during the period of adolescence. At the post-mortem the kidneys show signs of extensive interstitial nephritis, with occasional cyst formations. The chief interest in the condition, from the surgical point of view, is the necessity for its recognition, as any attempt at operation under anæsthesia will most probably end in a fatality Very occasionally the patient appears to outgrow the disease, the amount of urine secreted diminishes, the radiographic appearances become normal, and the patient appears to have completely recovered.

TREATMENT

Moulding of the deformities by means of splints, or the wearing of irons, may occasionally be advisable.

ACROMEGALY

A disease which first appears in adult life after skeletal growth has ceased, and characterized by enlargement of the hands, feet, head and face. The bones of the extremities show some slight increase in size, but the changes affect chiefly the soft tissues.

The disease is always associated with a tumour of the pituitary body. This tumour is usually a simple adenomatous enlargement of the anterior lobe of the gland. With the enlargement of the soft tissues the head is particularly involved, the orbital and zygomatic arches becoming more prominent, the nose increased in size both transversely and vertically, the ears being large and the lower lip prominent. The hands and feet are also distinctly enlarged, and the patient's movements are usually slow and cumbersome. As the tumour enlarges it may, on account of its size, give rise to constant headache, for which advice is commonly sought.

Treatment

In the early stages of the disease a successful removal of the pituitary tumour results in the arrest of the disease. In the later stages symptomatic treatment may produce some relief of symptoms.

OSTEOMALACIA

The term osteomalacia is used to describe a condition in which, owing to some unknown cause, there is a general absorption of lime salts from the bones, which become extremely thin in texture, bending easily and frequently fracturing from slight violence. As a rule, the condition occurs in women and is apparently related to pregnancy. After childbirth the progress of the condition may cease, but it again becomes active on each succeeding pregnancy, especially if these occur at short intervals.

Another type of the disease occurs occasionally in children or in young adults. In the radiographic appearances and the clinical signs this type is identical with the more common variety.

Etiology

Owing to the close association of the disease with pregnancy it has been suggested that the disease is caused by an endocrine disturbance, originating in the ovary. This explanation may apply to the more common type but it cannot be applicable in every case.

Clinical History

As a rule, the patient, a pregnant woman, complains of gradually increasing pain and aching in the loin and pelvis, associated with a general muscular weakness and, in the later stages, with extreme deformities of the skeleton due to softening and fractures.

Pathology

The bone changes are caused by a generalized disappearance of lime salts from their structure; the cancellous bone disappears and is replaced by vascular cellular tissue, in which osteoid tissue is deposited. The bone at this stage is *extremely soft, and can be cut by a knife. The periosteum* is thickened and hyperæmic; the Haversian canals are increased in size and may be lined by weak osteoid tissue. Cysts may be present at any part of the affected bone.

Diagnosis

In the common type occurring in a pregnant woman, the gradually increasing deformities and the peculiar radiographic appearances of the bones, which cast a very poor shadow on the film, are quite sufficient to differentiate the condition from other general bone diseases.

When encountered in children considerable difficulty may be experienced in differentiating the condition from fragilitas ossium. Diagnosis rests on the occurrence of bending of the unbroken bones, which is so common in osteomalacia.

Treatment

Endocrine therapy, although persisted in, has been of little or no value. Open air, good food and exercise, within the strength of the patient, will increase the general metabolism and lead to an improvement in the disease itself.

As the condition is so commonly associated with pregnancy the removal of the ovaries, or the destruction of their activity by means of deep X-ray therapy, holds out the greatest hope, and has on many occasions led to a complete cessation of the progress of the disease, an improvement which *did not occur under any other form of treatment.*

DYSCHONDROPLASIA OR DIAPHYSEAL ACLASIA

This condition, which is congenital in origin, occurs more frequently in males than in females. It is characterized by the presence of multiple bony outgrowths, which are present towards the ends of the long bones, in a patient who is shorter than normal and to whom the description of "dwarf" is frequently applied. An interesting clinical feature is the frequent familial tendency shown by this disease, which has been known to occur in four generations of one family.

Pathology

The pathological changes are seen at those sites where the two types of bone formation from cartilage and membrane come together. The

disturbances of growth are greatest in those regions where growth is normally most active; thus, the shoulder, wrist and knee areas show the greatest changes.

At the ends of the diaphysis, close to the epiphyseal line, the surface of the bone cortex is broken, with the result that the cancellous bone protrudes in one or several directions, forming osseous outgrowths of irregular shape. This abnormal mass is, up to the age of 20 years, covered by a cap of cartilage, which may act as an epiphysis and may continue to grow. As growth proceeds the bony tumour, which developed near the epiphyseal line, may become separated from its place of origin by the growth of healthy bone between it and the epiphyseal plate. The ends of the diaphyses also show great irregularity, isolated areas of irregular placed bone cells being separated in parts by islands of cartilage (Fig. 182).

Clinical Picture

The patient is usually small but quite strong and active. The disturbances of growth, which have led to the formation of osseous tumours, have also resulted in a diminution in the normal growth of the long bones. The tumours themselves usually cause little or no inconvenience, but, if abnormally large or if pressing on some important structure, they may require operative removal. Occasionally also, removal of one or more of the bony tumours is demanded by the patient on account of the obvious deformity of an area, such as the wrist, which is uncovered by clothes. Otherwise no treatment is necessary.

OSTEOMYELITIS

Pyogenic infection of bone, or osteomyelitis, is invariably the result of the deposit and growth of organisms in the bone tissues. Any type of pyogenic organism may be responsible for the disease, and the effect produced depends on the virulence of the bacteria, and the resist-

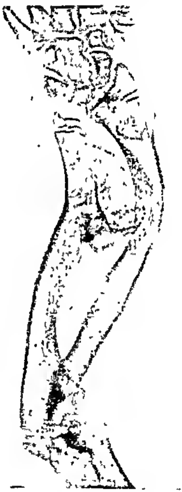


Fig. 182.—Diaphyseal Aclasia affecting the Arm.

ance of the tissues, rather than on any specific action peculiar to one particular type of organism.

Although almost any type of organism may be responsible for the onset of osteomyelitis; the disease in at least 75 per cent of cases is the result of infection by the staphylococcus aureus. Almost identical signs and symptoms follow the growth of the streptococcus, pneumococcus, *bacillus coli*, and many others, and it is impossible from the clinical signs of osteomyelitis to determine the type of organism which is responsible for the infection.

The infection may reach the bone by.

1. The blood-stream, which carries the organism from a distant source of infection, commonly an infected pustule.
2. Direct spread from a neighbouring infected area.
3. Punctured wounds or compound fracture.

Although most of the organisms which cause the disease are normally present in the body, they only settle and produce osteomyelitis under favourable conditions. Ideal conditions for the development and growth of the bacteria commonly follow local injury, when there is developed an area of lowered vitality, in the centre of which lies a hæmatoma, which forms an ideal bed for bacterial development Any strain or injury to the bone, not sufficiently severe to produce a fracture, exerts its maximum effect on the epiphyseal plate and on the highly vascular neighbouring portion of the diaphysis.

It would seem that, in addition to the presence of the infecting organisms and conditions suitable for their growth, there is usually also a third factor of a poor general resistance on the part of the patient. This appears to be an important predisposing cause of the disease, as evidenced by the fact that acute osteomyelitis develops almost invariably in children who are improperly nourished, and who live in crowded insanitary conditions

Occurrence

Acute osteomyelitis is essentially a disease of childhood, at least 80 per cent of the cases not caused by open wounds occurring in the first 10 years of life. Boys are more frequently affected than girls, in the proportion of 4 to 1, and although any bone may be the site of disease the infection is found more commonly in the tibia than in any other bone. Its more frequent occurrence in boys, and its predilection for the tibia, suggest strongly the great influence exerted by injury as a predisposing factor of the disease.

Site and Course of Infection

The usual primary site of infection in acute osteomyelitis is the metaphyseal area, the highly vascular portion of the diaphysis which lies in contact with the epiphyseal plate. This may be accepted as the common

site of deposit and growth of the infecting bacteria, from which spread may occur in several directions. Instances of infection starting in the middle of the bone are not uncommon, and are probably the result of direct trauma, followed by blood-borne infections of the injured area. Depending on the virulence of the infection and on the power of the patient's resistance, the course of the disease varies from an acute spreading infection of the whole bone, with great prostration and high temperature, to a localized invasion, in which the infected area becomes surrounded and shut off by a ring of bone sclerosis, a condition which is accompanied by few signs of general septic infection.

As a rule, from the primary focus in the metaphyseal area, the infection spreads along the medullary canal, and from this through the perforating channels of the cortex of the bone, to form a sub-periosteal abscess. Occasionally the spread is almost entirely confined to the cortical and sub-periosteal region, in which a large abscess may be present with little or no medullary involvement. On the other hand, the infection may spread widely along the medulla without showing much sub-periosteal involvement. According to Starr, this is not the usual route taken by the spreading infection; he believes that from its focus in the metaphysis the infection spreads under the epiphysis to the sub-periosteal area. Here it may remain localized or may spread for some distance. Frequently from the sub-periosteal infected mass, bacteria enter the medulla through the Haversian canals, and secondary infection of the medulla at a distance from the primary focus is developed in this manner.

As the infection spreads, the vessels entering the bone from the periosteum become thrombosed, leading to an anæmia of the infected bone with the eventual necrosis and death of the part so isolated. If the infection has become diffused, and has extended all round the bone under the periosteum, this necrosis of bone may be complete and the whole shaft may form a single sequestrum. As a rule, the area involved is localized, and one side of the bone or even a superficial layer alone may become cut off and form a sequestrum. When the bone infection has been present for some considerable time the deep layer of the periosteum, the active bone-forming tissue, throws out from its surface new bone to form a complete or partial envelope of new bone, extending over the outer aspect of the sequestrum. This new shell or involucrum is usually incomplete, being punctuated by openings called cloacæ, through which discharge from the necrotic mass may reach the subcutaneous tissue and the surface of the limb.

Clinical History

With or without a definite history of injury, there is usually a story of rapidly increasing pain and tenderness in the affected area, with a continuous deterioration of the patient's general condition. The tongue becomes furred, the temperature is raised, and, depending on the resist-

ance of the patient and the virulence of the infection; the acute symptoms may settle down, or the child may become steadily worse and eventually pass into a state of coma. The affected limb gradually becomes more swollen and red, with a generalized tenderness, which is more severe over the affected bone, especially round the area of primary infection.

Examination of the blood indicates a considerable increase in the leucocytic count, the figure sometimes being as high as 25,000, but, in the very acute infections, in which the child's resistance is particularly low, the leucocyte count may be normal or even sub-normal. Pathological organisms are usually found in the blood during the whole course of the disease. If the disease progresses, the local signs are soon obscured by the deterioriation of the patient's general condition, and the final stage is, as a rule, ushered in with delirium, coma and extreme hyperpyrexia.

If, in this extremely acute type, the area of infection is opened, it will be found that no pus has been formed, the whole bone being bathed in a serous exudate, which is present under the periosteum and surrounds the bone completely. These cases of extremely acute infection, although fortunately rare, have a very high mortality rate.

Differential Diagnosis

The two clinical conditions which give rise to most difficulty in differential diagnosis are rheumatism and cellulitis.

Rheumatism. The diagnosis of rheumatism is unfortunately too frequently given as an explanation of persistent pain and rise of temperature The differentiation between the two conditions should be comparatively simple. In osteomyelitis the pain is localized to one area and does not flit about as in rheumatism, and the swelling and tenderness are localized over a bone and not over a joint. Examination of the blood, and appreciation of the great increase of white blood corpuscles, should dispel any doubts in the less acute infections.

Cellulitis. The presence of a widespread cellulitis over a limb may cause considerable doubts as to the correct diagnosis. In some cases differentiation from acute osteomyelitis is extremely difficult, but the absence of the localization of the swelling to the region of the bone, the equal involvement of the soft tissues all round the limb, and the fact that tenderness is not so extreme, all help to indicate the diagnosis of cellulitis.

Treatment

The type of treatment which should be adopted in any case of acute osteomyelitis depends on several factors, of which the following are the most important:

1. The site of the disease.
2. The age of the patient.
3. The duration of the infection.

1. The Site of the Disease. Infection occurring in cancellous bone, such as the os calcis, the ilium or the great trochanter tends to be more localized and less virulent than that occurring in the long bones. For this reason operative interference should as a rule be postponed and may be rendered unnecessary by the administration of penicillin during the period of observation.

Small doses are of little value; they obscure the clinical signs and do not prevent spread of the infection. At least 500,000 units should be given daily for a period of 3 weeks, and during this waiting period the affected area must be immobilized and protected.

2. The Age of the Patient. When very young children are affected by acute osteomyelitis operative interference is usually unnecessary and inadvisable. When first seen the child is always dehydrated, a condition which causes very poor resistance. The general condition is rapidly improved by the administrations of fluids both by mouth and intravenously. With the improvement of the general condition the infection become localized and, as a rule, an abscess appears and opening becomes necessary.

Direct treatment of the infection depends on the administration of penicillin, which should be given to the extent of a quarter of a million units daily. Even these apparently large doses produce no ill effects and, as a rule, opening of the area of infected bone is not required.

3. The Duration of the Infection. The prognosis depends largely on the length of time which has intervened between the onset of the infection and the commencement of treatment, although it is to some extent also dependent on the virulence of the infective organism and the resistance of the patient.

The discovery of the beneficial effects of penicillin has greatly modified the lines of treatment which should be employed in combating acute osteomyelitis. Before penicillin therapy was recognized and accepted much discussion took place on the advantages of the different surgical methods of dealing with the bone infection.

The methods in general use were:

1. *Complete immobilization of the infected limb* in a plaster case until the disease became localized, when removal of extensive sequestra was usually necessary.

2. *Guttering of the infected bone*, by which was meant the removal of a wide strip of cortex from the infected area of bone, the limit of the removal being the point at which the periosteum was normal in its attachment to the underlying bone.

3. *Subperiosteal resection* of the whole of the infected bone, an ideal method of removal of all infected tissue, but if carried out before the deposit of new bone from the periosteum, usually followed by non-union.

4. *Metaphyseal drilling* as advocated by Starr of Toronto, the object being the provision of a line of escape for the infective organism.

Treatment of acute osteomyelitis consists primarily in the administration to the patient of adequate doses of penicillin, the recognized dosage being 500,000 units per day for a period of 3 weeks. This is given by injection every 4 hours and the administration does not seem to upset or worry even the youngest patient. By the use of smaller doses the temperatures can be controlled and the general condition of the patient improves, but the spread of infection continues.

In every instance of acute osteomyelitis in a patient of more than 1 year of age, metaphyseal drilling should be used in the infected area. Proof of the value of drilling is gained by the work of McKee and of Tucker and Hollenburg, whose figures demonstrate clearly that by drilling, spread of the disease is prevented and recurrences of bone infection are minimal.

Metaphyseal Drilling

The site of infection is first determined before the administration of anæsthesia and an incision made over this aspect of the metaphysis down to the periosteum. This may be found swollen and infiltrated and this localized inflammatory area can be taken as an indication of underlying infection. Cutting and elevation of the periosteum is not necessary or advisable; the drill should be placed on the periosteum close to the metaphysis and the periosteum and bone drilled at this point.

Drilling at too great a distance from the metaphysis is a common error and cannot give relief at the desired point. When pus has been found further drill holes may be added slightly more distant from the metaphyseal plate. When three or four drill holes have been made in the line of the bone, the operation should be completed by suture of the skin wound and immobilization of the limb.

The results obtained by this line of treatment are immeasurably better than those following drilling or guttering of the bone without the use of penicillin, and following this procedure the child may leave hospital in 4 weeks and may return to school in another fortnight.

CHRONIC OSTEOMYELITIS

Persistent discharge from an area of bone infection over many months or years is due, in most instances, to the presence in the bone of a large cavity lined by granulation tissue in which there may be one or several sequestra. Chronic osteomyelitis of this type with persistent discharging sinus may follow on acute osteomyelitis of one of the long bones, but is seen more frequently following infection of a cancellous bone. Thus, osteomyelitis of the great trochanter, lower end of the femur, or upper

end of the tibia, is often followed by a chronic discharge, persisting for 20 or 30 years, with little or no variation in its amount or in the condition of the patient.

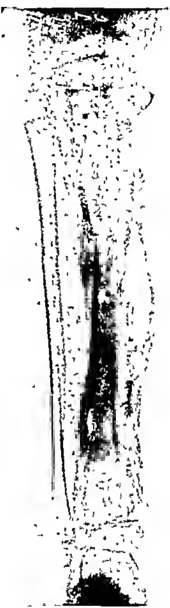


Fig. 183—Chronic Osteomyelitis with sequestrum formation in shaft of Tibia.

Treatment

Unfortunately the great benefit which is obtained by the use of penicillin in acute osteomyelitis is not seen following its administration to a patient suffering from chronic osteomyelitis. As a result of the long-continued infection of the area the blood supply is diminished and little improvement follows the administration.

If one or more definite sequestra can be identified (Fig. 183), these should be removed through a comparatively small opening with good prospects of complete recovery, but, in the case of chronic cancellous bone infection, the method of Winnett Orr holds out the best hope of cure.

In this, the area is widely opened up, any obviously infected bone being removed, together with a thin layer of subjacent healthy bone. The whole cavity is then dried and swabbed with 10 per cent of iodine, followed by cleansing with 95 per cent alcohol, after which it is filled with vaseline-soaked gauze, and the whole limb encased in a complete plaster-of-Paris cast, which assures immobilization. The cavity gradually fills with granulation tissue, and any minute sequestra, which have been left in situ, will usually find their way to the surface of the wound. The dressing and plaster case should not be altered for 4–6 weeks, the only indications for alteration of the dressing being a severe rise of temperature, or the onset of severe pain.

Occasionally, in spite of all methods of treatment, chronic osteomyelitis persists, and may after a long period produce signs of kidney infection with albumen and casts in the urine. If the general health is being undermined, amputation of

the affected limb is the only suitable line of treatment, and its application should not be too long delayed.

PYOGENIC INFECTION OF JOINTS

Infection of a joint follows the introduction of almost any of the pathogenic organisms. Thus, suppurative infection has followed the admission to the joint of such organisms as the bacillus of diphtheria, or the bacillus of influenza, but, as a rule, infection is caused by the staphylococci, pneumococci, gonococci or streptococci. The organisms may gain entrance to the joint by lymphatic spread, by pyæmic deposit from a distant source of infection, by direct extension of infection from a neighbouring area, or through the medium of punctured wounds.

Clinical History of a Closed Joint Infection

The clinical history of any case of joint infection varies according to the resistance of the patient, and the particular organism which has caused the infection, although, in most cases, it is impossible to decide by clinical means alone the type of organism which has produced the infection. The almost invariable reaction of a joint to the admission of organisms is the outpouring of fluid into its cavity. This fluid varies, and may be of a serous, sero-fibrinous or purulent character Thus, any of the common infecting organisms may, under suitable circumstances, lead to any of these three types of joint infection, and the clinical signs produced by each type vary with the extent of the destruction of the joint tissues.

As a rule, after admission of organisms to the joint the patient's temperature rises rapidly, the affected joint becomes swollen, red and tender, movements—either voluntary or passive—are extremely painful or absent, and the joint takes up a definite fixed position. When sufficiently superficial to be palpated, fluctuation can be felt and, if untreated, the contents may burst through the capsule and spread subcutaneously or on the skin surface.

The effect produced on the synovial membrane of the joint, and on the peri-articular tissues, varies with the particular type of infection. Thus, with serous effusion the synovial membrane is infiltrated and swollen, the blood vessels are increased in size, but the smooth synovial surface is unaffected.

With the sero-fibrinous type, the synovial lining is greatly thickened; fibrinous patches containing polymorphonuclear leucocytes and red blood cells are formed on the surface of the membrane, the articular cartilage covering the bone ends remains normal, although occasionally similar patches may appear there at a later stage. The peri-articular tissues are

infiltrated with small round cells, which also invade the ligaments and capsule.

In the purely purulent infection, all these changes are present to an exaggerated degree, the synovia and capsule being infiltrated and thickened, the blood vessels being dilated and engorged, and the surface of the synovial membrane showing areas of necrosis and fatty degeneration. The joint is distended with fluid containing large numbers of polymorphonuclear leucocytes, broken-down red blood corpuscles and large numbers of the infecting organisms. If the infective process remains localized to the soft tissues and does not involve the bony structure, the condition remains as a suppurative synovitis, but, as a rule, the articular surface becomes involved at a later stage, so constituting a true suppurative arthritis, which invariably leads to a generalized disintegration of all the joint structures.

Joint Infection due to Penetrating Wounds

Following the opening of a joint by a foreign body there is, as a rule, little general reaction during the first 12 hours, the local signs being the escape of joint fluid and blood through the wound. If the wound is not adequately treated in the first few hours infection of the joint is to be expected, the infiltration of the synovia and perisynovial tissues being the same as that already described in infections of the joint.

The success of treatment depends on the interval between the injury and the excision of the injured tissues. As soon as possible the wound in the skin, subcutaneous tissues and synovial membrane should be excised, the foreign body, if present, being removed and the joint washed out with saline, the various tissues being sewn up in layers. If the operation has been performed efficiently during the first 6 hours, infection is usually prevented, but if delayed beyond the 12-hour interval infection is the rule. Help in preventing the onset of infection in these late cases is given by the use of penicillin, which may be applied locally to the injured tissue or given by injection as in the treatment of acute infections.

Treatment of Closed Joint Infection

When definite signs of infection of a single joint are present with swelling, tenderness, pain and rise of temperature, aspiration and bacteriological examination of the joint contents are advisable. If the fluid removed is of the serous type and contains few or no bacteria, the joint should, after aspiration, be firmly bandaged over a thick layer of cotton wool, so that an equal steady pressure is maintained for at least 48 hours. A single aspiration may be sufficient, but, in the presence of a recurrence of swelling, the aspiration may be repeated and the same routine followed

if the fluid removed is of the semi-innocent character. When all fluid has disappeared active use of the joint is encouraged, and a restoration of full function is to be expected.

Sero-fibrinous Infection

If, after aspiration, the fluid removed from the joint shows definite flakes of fibrinous material and appears turbid, simple aspiration is usually insufficient to prevent a recurrence. Under these circumstances, following the aspiration penicillin may be injected into the joint and the treatment continued by giving the usual daily dose of penicillin for a period of 3 weeks. Where the infection of the joint is not a complication of disease of one of the neighbouring bones the result is usually excellent, and a full range of movement may be expected.

The infection may also be treated effectively by aspiration of the contents of the joint followed by filling the joint cavity with ether which can be injected through the same needle. The amount of ether used varies with the size of the joint, and must be injected solely into the joint cavity, none being allowed to escape into the peri-articular tissues. Anæsthesia is essential when using this method, as the process is an extremely painful one, but after recovery from the anæsthesia little pain is experienced, and the patient complains solely of a feeling of distension of the joint.

This form of treatment has proved to be of the very greatest value in the suppurative infections of the knee, shoulder and ankle, and its value as a therapeutic measure has been frequently demonstrated. Occasionally, after one injection of ether, there is a rapid reappearance of fluid in the joint; if this occurs further aspiration and injection should not be undertaken, the joint should then be opened up and washed out with saline.

If the joint infection is a complication of infection in a neighbouring area, treatment must be directed towards the removal of this disease. It is obvious that treatment of the joint infection alone will be followed by the reappearance of the articular infection, unless the area of disease has been efficiently treated.

Opening and Washing the Infected Joint

If the joint is sufficiently near the surface, two incisions are made into its cavity on opposite sides, the nozzle of a Higginson's syringe is introduced through one opening, and the cavity is then washed out with saline solution until all traces of discoloration of the fluid have disappeared. No antiseptic should be used, reliance being placed solely on the amount of fluid used in the washing. No sutures should be inserted into the incisions, which are left open and allowed to granulate, and no form of drainage tube or wick should be employed because of the great danger of

the development of fibrous ankylosis. Active movements of the joint are encouraged when the wound has begun to granulate, but passive movements should never be employed.

Active Mobilization of Infected Joints

Willems has suggested the treatment of suppurative joint infections by wide opening, followed by active movements, in order that the movement of the muscles and bones may squeeze out the purulent contents. Such movements are extremely painful, and the pain caused by the attempts at movement has been so great that the patient has almost invariably refused to persist in the effort.

GONOCOCCAL ARTHRITIS

This type of joint infection appears, as a rule, suddenly about the end of the third week of urethral infection. Occasionally it appears at a later stage of the disease when the original infection is represented by a chronic gleet, in some cases after the reactivization of the disease by the passage of instruments. The reaction produced in the joint may be of the serous, sero-fibrinous or purulent type, that most commonly seen being a serous effusion with a considerable peri-articular œdema. The synovial membrane becomes boggy and thickened and, if the effusion is examined microscopically, the gonococcus may be found during the first 10 days, but rarely at a later stage.

When the joint fluid is of the sero-fibrinous type the synovial membrane is not only thickened but its surface is covered by patchy areas of granulation tissue. The articular cartilages rarely escape; as a rule, the surface of the cartilage is destroyed, the superficial layers being shed. Pit-like cavities appear on its surface, and these later become the points of adherence of firm fibrous bands which pass between the articular ends of the neighbouring bones. Definite purulent infection of the joint is a rare phenomenon. When present it produces more severe general and local reactions, with destruction of the articular surfaces and the formation of particularly dense fibrous masses, and great interference with subsequent function of the joint. The peri-articular infiltration, which involves tendons, ligaments and capsule, is an outstanding feature of all types of gonococcal joint infection, and when the true joint changes have disappeared the peri-articular infiltration may of itself produce a serious loss of function.

The outstanding clinical feature of the gonococcal joint infection is the severity of the pain produced, even in the serous and more especially in the sero-fibrinous or purulent type. The onset is sudden and may be accompanied by a rigor; the skin over the joint becomes red and hot,

and, if purulent infection has supervened, all the signs and symptoms are exaggerated.

Diagnosis

Little difficulty is encountered in the acute type in its early stages, and confirmation can then be obtained by aspiration of fluid from the joint, but, in the more chronic type, in which the chief clinical signs are thickening and infiltration of the synovial membrane and perisynovial tissues, a differential diagnosis from tuberculous infection may only be possible after an arthrotomy.

Treatment

In this disease penicillin is so effective that, after a few injections there is a rapid diminution in the swelling, pain and infiltration of the joint. The treatment should be continued for at least 3 weeks, and complete restoration of movement is the rule if treatment is begun early. If destruction of the synovial lining and articular surfaces has already

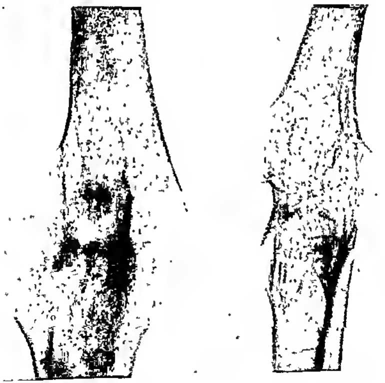


Fig. 184.—Bony Ankylosis following Acute Suppurative Arthritis of Knee-joint.

occurred, the movements of the joint must be limited or lost. Locally, aspiration of the joint is of value, and the injection of penicillin into the infected joint cavity hastens the recovery.

If after the disappearance of the acute infection adhesions have formed, the surgeon will have to decide, by clinical and radiographic examinations, whether forced passive movements of the joint are likely to be followed by an increased range of active movements, or whether it is preferable to leave the joint in its position of maximum utility with a sound fibrous ankylosis (Fig. 184). The decision rests largely on the condition of the articular surfaces, which may or may not be involved in the destructive processes.

PNEUMOCOCCAL ARTHRITIS

This condition, although rare, is occasionally seen in the course of some other disease, such as pneumonia or otitis media. It has been stated that primary or idiopathic joint infections of this type do occur, but this observation is probably faulty, and the original infection has been overlooked.

As a rule, only one joint is involved, the larger joints, such as the hip or knee, being most frequently attacked. The reaction in the joint may consist of a thickening and infiltration of the synovial membrane with a serous effusion, or may be definitely purulent with extensive disintegration of all the joint structures.

Onset

The onset of pneumococcal arthritis is, as a rule, not so acute as that of gonococcal arthritis. As the patient is usually already ill from the pneumococcal infection, the onset of arthritis leads to an increase in the general signs of infection which are already present. The joint becomes swollen and red ; any movements, either active or passive, are extremely painful and are strongly resisted. Confirmation of the diagnosis can be gained by aspiration of the joint, when the pneumococci can be identified.

Prognosis

Owing to the fact that before the onset of the pneumococcal arthritis the patient was already suffering from a serous infection, and had a diminished power of resistance, the prognosis is grave in this disease. In at least 50 per cent of cases reported over many years the disease has had a fatal result in spite of efficient treatment.

Treatment

Aspiration of the swollen joint should be carried out at the earliest possible moment, because by the early removal of its infected contents,

it may be possible to prevent the change from a serous to a definitely purulent infection. Aspiration in the serous type is usually sufficient of itself, but repetition of the aspiration may be necessary after 2 or 3 days on account of a recurrence of the effusion.

When the infection is definitely sero-fibrinous or purulent, aspiration again may be the only possible form of treatment on account of the patient's low resistance. If it is possible to use any form of anæsthesia, the joint should, after a double opening, be washed out with saline, and *active movements encouraged when the patient is able to make the effort.*

CHAPTER XXV

TUMOURS OF BONE

Bone tumours may be classified according to the tissue from which they arise as osteoblastic, fibroblastic, cartilaginous, etc., but the simplest classification depends on the character of the growth, which gives the two main sub-divisions of bony tumours:

(*a*) Simple.
(*b*) Malignant.

SIMPLE TUMOURS

EXOSTOSES

An exostosis is a benign tumour occurring in children between 10 and 20 years of age, originating, as a rule, near the end of one of the long bones. The tumour may be broad-based or pedunculated, the latter type being the more common. In structure the growth consists of laminated layers of bone, covered by a layer of cartilage which may show signs of calcification, the whole being surrounded by a thin membrane of fibrous tissue.

Clinical Signs

In many instances there is a distinct family history that similar bony growths have been found in several members of the same family, while very occasionally the development of the tumour appears to be associated with injury.

Although an exostosis may occasionally be found in connection with almost any bone, there are certain sites which show a special predilection for the growth; thus, in almost 75 per cent the tumour arises from the lower end of the femur or the upper end of the tibia.

Symptoms attributable to the presence of the exostosis usually develop only when the tumour interferes with the normal action of the adjacent joint, muscle or tendon, or when, on account of its presence, a bursa has formed between it and the skin.

Radiographic Appearance

The base of the exostosis shows clearly as a continuation of the normal cortex of the surrounding bone, no differentiation of the tumour tissue from the normal bone being apparent. The cartilaginous cap may be suggested as an indefinite shadow covering the apex of the exostosis, or the cartilage may be impregnated by calcification which,

in the typical picture, shows an irregularly round cap on the apex of the tumour.

Etiology

In the case of true so-called congenital exostosis arising in children, the cause of the growth would appear to be an inherited weakness of the periosteal covering of the bone. *Owing to this weakness of the* limiting membrane part of the underlying cartilaginous bone escapes from its normal envelope, enlarges and forms the new growth. After the development of the exostosis the continuation in the growth of the parent bone leads to the displacement of the tumour from its original site, so that eventually it may appear at some considerable distance from the active growing end from which it originated.

Treatment

As a rule, a small exostosis causes no disability or pain to the patient and does not require treatment. If, owing to its situation, function is interfered with, or pain is caused by pressure, the tumour should be removed.

In its removal the cartilaginous cap and the fibrous cover should be removed in one unbroken piece, together with the tumour and the *subjacent area of normal bone, the raw surface of bone left after operation* being hammered, or covered with Horsley's wax, in an effort to prevent re-formation of the bony tissue.

CHONDROMATA

The typical chondroma, which may be single or multiple, is a simple tumour occurring most commonly in the small bones of the hands and feet. In the phalanges it occurs as a smooth cavity in the affected bone, surrounded by a shell of cortical bone.

Radiographic Appearances

These show a centrally placed cystic cavity in the affected bone, surrounded by a thinned and expanded cortex. As a rule, no trabeculæ are present in the cavity, although faint lines may occasionally be visible (Fig. 185). No other tumour produces central bone destruction in a phalanx so frequently as chondromata—bone cysts and giant-cell tumours, which produce somewhat similar radiographic appearances, occurring more frequently in the metacarpals and metatarsals.

Chondromata are also found occasionally in other situations, the costochondral junctions or the sternum itself being the most frequently affected, although growths of similar type are found in the long bones and in the scapula or pelvis.

FIG. 185.—Chondroma of Shaft of 5th Metacarpal.

Microscopically

The tumour may consist of a single solid cartilaginous mass, or may be divided into sections separated by fibrous septa. In these subdivisions of the cartilaginous growth, gelatinous material of a myxomatous type is frequently found, whilst occasionally calcification occurs in the fibrous lamellæ.

History

As a rule, progress of chondroma is that of a true simple tumour, which gives rise to symptoms only on account of its position or size. Occasionally, owing to an alteration in the nature of the growth, it undergoes expansion with a rapid development of its local signs and symptoms. Thus, a tumour which has remained simple for many years may, without apparent cause, be converted into a chondromyxoma, a chondrosarcoma, or a chondromyxosarcoma, a change which gravely alters the prognosis and modifies the line of treatment to be adopted.

Treatment of Chondromata

If causing pain or disability the cartilaginous tissue should be removed by operation. The cavity of the tumour is easily opened through the thinned cortical bone, the contents are then evacuated by the use of a

spoon, and the adjacent bony walls crushed inwards to diminish the size of the cavity, and to stimulate its closure by new bone formation. The possible prevention of the redevelopment of the tumour by the use of thermal or chemical agents on the cavity walls is still under discussion, although it would appear that such agents can deal only with the surface tissue. Occasionally, when a very large cavity remains after removal of the tumour, its extent may be diminished, and bone formation stimulated by the implantation of one or more autogenous bone chips or grafts.

BENIGN GIANT CELL TUMOUR

Benign giant cell tumour is essentially a disease of young adult life, and is closely related in its site to the position occupied by an epiphysis, where osteogenesis by cartilage has taken place. The tumour *appears most commonly between 15 and 30 years of age*, the most frequent sites being the lower end of the femur, the *upper end* of the tibia, and the lower end of the radius.

History

A history of trauma is frequently obtained in the examination of such a tumour. Many instances of the gradual development of a giant cell tumour following injury have been discovered, and proved by a series of radiographs taken at intervals following an injury, which apparently produced no lesion of the bone. Although the tumour leads to expansion of the parent bone, and may perforate the cortex at one side, it rarely leads to secondary deposits, local recurrence after operation being considered as evidence of imperfect removal.

Clinical Features

Gradually increasing discomfort rather than pain develops over the site of the growth. The tumour increases in size and usually interferes with the function of the neighbouring joint. Fracture through the *weakened bone may occur in the later stages*, or may be the first indications of the pathological change.

Radiographic Appearances

In the radiograph a cavity appears near the articular end of one of the long bones; this cavity is not clear cut and rounded like a chondroma, but is essentially irregular in outline with extremely thin cortical bone, which, as a rule, remains unbroken until *a very late stage*. Trabeculæ may be seen to traverse the growth in its early stages, but with increasing size these tend to disappear (Fig. 186). No periosteal

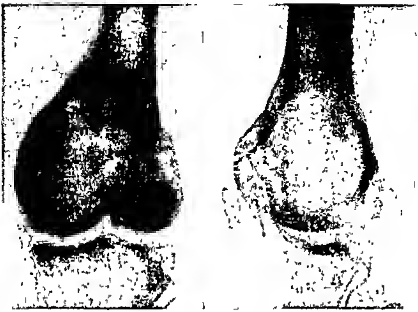


FIG. 186.—Benign Giant Cell Tumour, lower end of femur, showing typical appearance involving the whole of the lower end of the bone.

reaction is produced by the presence of these tumours, whilst there is a well-marked line of demarcation between the tumour and the healthy neighbouring bone, two points of great importance in the differential diagnosis of giant cell tumour from osteosarcoma.

Appearance of the Tumour

Macroscopically the tumour is very hæmorrhagic, varying at different parts from red to black, fibrous septa can be seen extending inwards from the capsule.

Microscopically the tumour is composed of small round cells with large nuclei and little cytoplasm, between which are embedded large multinuclear giant cells. These are present in large numbers and have many nuclei, and can be distinguished from the more scattered giant cells, containing few nuclei, which are found in osteitis fibrosa and osteogenic sarcoma. In many areas the tumour shows signs of old or *recent hæmorrhage, while thin-walled blood vessels traverse its substance.*

Treatment

The type of treatment which should be employed depends largely on the situation of the tumour and on the stage at which treatment has been instituted. Where the affected bone is not too widely destroyed, curettage of the growth is usually adequate. In advanced cases, par-

ticularly when the tumour affects the fibula, ulna or radius, resection of the affected bone is probably the best form of treatment. When the tumour has recurred after efficient curettage, resection of the affected bone is the treatment of choice, unless the bone affected be the tibia, femur, or humerus, where resection is usually followed by a flail and useless limb. When one of these three bones is the site of a recurrence, further clearing out of the cavity is advisable, and this procedure may, with advantage, be followed by filling the cavity with large bone chips. When infection has occurred at the site of operation, or when by extensive destruction of bone the limb is rendered useless, amputation is advisable and should not be delayed.

When the skull, spine, sternum, etc., are affected, deep X-ray therapy may be employed, but without any great assurance of cure of the condition.

MALIGNANT TUMOURS

OSTEOGENIC SARCOMA

This term "osteogenic sarcoma" is now generally used to include the two older subdivisions, periosteal and endosteal sarcoma. It has been commonly accepted that such a term, which is used to indicate the origin of the tumour from bone-forming cells, is preferable to the older descriptions.

The commonest sites for the development of osteogenic sarcoma are the region of the knee, including the lower end of the femur and the upper end of the tibia, and the shoulder, where the upper end of the humerus and scapula are affected. Frequently, in association with true sarcomatous tissue, various other elements are found in the growth; these include bone, connective tissue and cartilage, of which the most common is the cartilaginous element.

From this fact, and from a consideration of its common site of origin in the diaphysis, it would appear that there is a close relation between the origin of this type of malignant growth and of the simple tumours, such as chondromata and osteomata. From its site of origin the tumour extends through the cortex of the bone and along the medulla. As it pierces the cortex it is at first held in check by the periosteum, but gradually this is raised and the tumour extends widely, to be arrested at the attachment of the periosteum at the epiphyseal line. In its spread along the medullary cavity it gradually absorbs the bone trabeculæ, with the result that the cavity of the medulla becomes filled with a highly vascular tumour mass, which may extend up to, but not through, the epiphyseal plate.

Microscopically the tumour varies according to the amount of cartilage, bone and blood vessels contained in it—a circumstance which has given

rise to the description of tumoors as chondrosarcoma, ostcosarcoma or the so-called malignant aneurism of bone. Fundamentally the tumour cells show the very earliest stages of cartilage formation from connective tissue; io fact, the tumour tissne may he said to represent the earliest type of uodifferentiated connective tissue concerned with ossification.

The cells commonly found are the small spindle-shaped fibroblasts, large polyhedral cells and small round cells. No one type of cell is found to the exclusion of the others, different parts of the tumour occasionally showing a preponderance of a different type of cell. The intercellular substance may be scanty or pleutiful, and may consist of myxomatous, cartilaginous, osteoid or osseous tissue; giant cells are found occasionally, especially in the rapidly advaocing or osteolytic tumour, and between the cell masses lie the thin-walled blood vessels.

Clinical Signs

The patient is usually in the second decade of life aod complains of a steadily increasiog swelling near the eod of one of the long hones, the enlargement being associated with considerable pain of an intermittent type. There may be a reliable history of iojury between 1 and 3 mooths hefore the ooset of the growth, but in many instances no such history is available. Whilst the patieot's general coodition is invariahly good up to a late stage of the disease, anæmia is a characteristic feature, while *locally* the skin hecomes thinned aad stretched, and is usually traversed by enlarged veins. The temperature may be raised to 100 or 102 degrees Fahrenheit, and the blood picture shows a leucocytosis with the white cell count hetween 12,000 and 15,000.

Although fracture of the bone may occur through the diseased area, the complicatioo is not so frequent as in the case of cyst of bone, probably because use of the limb is more restricted on account of the pain. At a late stage general dissemination of the growth commonly occurs and, whilst the lymphatics take some part in the spread, the main channel is through the blood-stream. Pulmonary metastases are especially frequent, and with the rise of temperature, leucocytosis and persistent cough a mistaken diagnosis of pneumonia may easily be made.

Radiographic Appearances

These naturally vary according to the type of growth present; thus, the appearance of osteolytic sarcoma, with its nibbling away and perforation of the bone shell, may easily be mistaken for a bone cyst. Again, in the sclerosing type of sarcoma the radiograph shows a dense mass of new houe, which tends to destroy the normal bony markings (Fig. 187). The periosteum is raised at the edge of the growth, and at this point

FIG 187 —Osteogenic Sarcoma of the Humerus with "sun-ray" appearance of periosteum

between the bone and the tumour a triangular mass of new bone appears, *and from the surface of the bone radiating spicules of new bone project* outwards at right angles to the shaft, giving the characteristic sun-ray *appearance.*

There are, however, certain features which are present in all the pictures. Thus, the affected bone shows both destruction and new bone formation, the soft tissues can be seen to be infiltrated, and the raised periosteum is indicated by the presence of a triangle of new bone at the edge of the growth.

Treatment

The treatment of osteogenic sarcoma is very unsatisfactory, and the outlook for the patient is particularly bad. The available forms of treatment are:

1. X-ray therapy.
2. Amputation or Resection
3. Injection of Coley's Fluid.

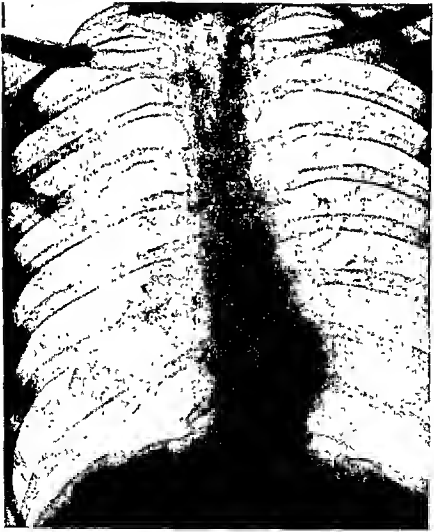


Fig. 188.—Secondary Sarcoma in Lung.

X-ray Therapy. The treatment of bone sarcoma *by a course of* deep X-ray therapy may, in skilful hands, lead to sclerosis of the tumour, with increase of the fibrous tissue stroma, or even increased bone formation leading to a retardation of the rate of growth, but, whilst such treatment may retard the growth of the primary tumour, it cannot prevent secondary metastases and cannot, therefore, prevent a fatal result.

At best, X-ray therapy is used as an adjuvant to surgery. A preliminary course may render operative removal of the growth or amputation less liable to be followed by recurrence, and after operation radiation of the chest seems to act as a mild preventative against the growth of secondary deposits.

Operation. The only operation which is justifiable in the treatment of sarcomata involving one of the bones of a limb is amputation. Even when this is carried out soon after the recognition of the tumour, secondary growths may have already occurred in the lungs (Fig. 188). In spite of this the operation is usually necessary for the removal of the source of constant pain. Amputation has one other advantage, it prevents the development of a protruding fungoid mass with a persistent blood-stained discharge, the dressing of which is an extremely painful process, which makes the patient's life miserable.

Injection of Coley's Fluid. The treatment of sarcomatous bone growths by the development of acute inflammation in the neighbouring *tissues was suggested by Coley, as a result of his observation that, following* local erysipelatous infection, a tumour in the neighbourhood either disappeared, or its rate of growth was retarded. Coley's fluid, which is used in this treatment, consists of a mixture of bacillus prodigiosus and bacillus erysipelatus. The fluid is injected into the neighbourhood of the growth, and into the growth itself, in such quantity that a very severe general reaction is produced. Unless the reaction is severe the effect of the injection is nil. The reports of cases treated by Coley are so good that the treatment deserves further trial.

EWING'S TUMOUR

This growth, which is also described under the titles of endothelioma or endothelial myeloma, has only been recognized as a clinical entity during the last 30 years. It is usually seen in patients between 15 and 25 years of age, males being affected more commonly than females, and *its occurrence is confined largely to the long bones, the tibia, fibula* and femur being the most frequent sites of growth.

The tumour grows almost invariably in the middle of the shaft of the bone, starting in the marrow—a site which distinguishes it from the osteogenic sarcomata and from the cysts of various types. In

structure it is semi-solid and of a greyish white colour, areas of hæmorrhage and cyst formation being comparatively common. In its progress the tumour extends along the medullary canal, destroying the lamellæ of the bone, and giving an appearance somewhat similar to that of a sub-acute osteomyelitis. It extends also through the Haversian canals and reaches the surface of the bone, new bone being laid down from the periosteum in plaques parallel to the surface of the bone—a condition which has been well described as "Onion-layers." As the tumour increases in size the innermost layers of new bone are absorbed, whilst new layers of bone are deposited on the outside, thus leading to a gradual increase in size of the tumour.

In structure the tumour consists of small round and polyhedral cells arranged in solid masses. The intercellular tissue is scanty, consisting of loose fibrous layers, and a distinguishing feature of the growth is the absence of giant cells in any part of the tumour. The lymphatic and blood vessels, which are thin-walled, frequently contain embolic masses of tumour cells; from these are developed secondary deposits in lymph nodes or bone, although any type of tissue may be the site of these deposits.

Clinical History

Frequently the appearance of the tumour follows on localized trauma; the history given is that the injury occurred some weeks or months previously, and the pain resulting from the original injury has as a rule, disappeared. Later, intermittent pain in the same region precedes the appearance of the slowly increasing tumour, which may approach but never involves the skin, clinical signs which suggest the diagnosis of sub-acute osteomyelitis. In the later stages of the disease secondary deposits appear in skull, ribs, pelvis, etc., and the appearance of these growths is accompanied by great wasting and rise of temperature.

Radiographic Appearances

Central rarefaction is seen in one of the long bones, at first the cortex is thinned over the central cystic area, but later, with the deposit of sub-periosteal bone, it becomes much thicker than normal. At a still later stage the cortex may become absorbed over a wide area, and at this stage, with widespread absorption and destruction of the shaft, the diagnosis of the tumour from the radiographic appearance alone may be extremely difficult.

Treatment

The use of deep X-ray therapy frequently results in diminution or even in disappearance of the tumour, but, even with the apparent cure of the primary growth, secondary deposits are comparatively common. For this reason it is preferable to amputate the affected limb after a

course of radiation, the amputation being followed by a second course of radiation of the chest in order to prevent secondary deposits.

MULTIPLE MYELOMATA

A rare condition of generalized growth in bone, which commonly affects ribs, pelvis, femur and spine as nodular masses, the size of the tumour varying from a pea to an orange. The tumours grow in the affected bones as rounded or oval masses of reddish-grey appearance. The bone trabeculæ and cortex are destroyed without the appearance of any new bone formation. Hæmorrhage and cyst formation are commonly seen in the tumour masses, and pathological fracture may precede extension of the tumour into the soft tissues. Changes in the central nervous system, the thorax, kidneys and blood usually follow at a later date.

Histology

The majority of the tumour cells are round or oval in shape, with an eccentrically placed nucleus. A smaller type of cell, resembling a lymphocyte, is also commonly present. A classification of myelomata, based on the structure of the cells found in the tumour, has been suggested, but such a classification is of little value, as all the different types of cell are usually present in every growth

Onset

The disease commonly affects adult males between 30 and 50 years of age, the onset is usually indefinite with intermittent wandering pains; gradually the pain becomes more constant and more severe. Deformities, such as kyphosis and bowing of the limbs, make their appearance until finally the patient becomes bedridden.

Differential Diagnosis

Difficulty is frequently experienced in distinguishing myelomatosis from carcinomatosis. The radiographic appearances are very similar, the affected bones showing punched-out areas of varying size without any new bone formation (Fig. 189).

Help in the diagnosis may be obtained from the discovery of a primary carcinoma in breast, prostate, uterus or thyroid, and, if thought necessary, a definite diagnosis may be made by biopsy. Some help may be derived from the Bence Jones reaction in the urine, but unfortunately reliance cannot be placed on the presence of this reaction as the proteose is absent in the urine of at least half the patients suffering from myelomatosis, whilst it may be present in leukæmia.

FIG. 189.—Multiple Myelomata of Upper Limb.

TREATMENT

Deep X-ray therapy holds out the only hope of relief of pain and discomfort, but the progress of the condition is certain.

SECONDARY MALIGNANT TUMOURS

Metastatic deposits of carcinoma may occur in bone following on primary growth in any tissue, but growths of the breast, prostate, kidney or suprarenal seem to be specially prone to give secondary osseous deposits (Fig. 190). These may be found in any bone—the vertebræ, humerus and femur being most frequently involved.

FIG. 190.—Secondary Malignant Deposit involving the Skull, following on primary Malignant Growth of the Suprarenal

CLINICAL FEATURES

The outstanding clinical feature of secondary carcinomatous deposit is the persistent severe pain which accompanies all deposits, especially those in which the vertebræ are involved.

Radiographic Appearance

The bone appears peculiarly mottled owing to the localized destruction (Fig. 191). Fractures may occur through the site of growth, and union of the fracture, although rare, occasionally takes place after a somewhat protracted period of immobilization.

Fig. 191.—Early Secondary Carcinoma of Neck of Femur

Treatment

The treatment of these secondary deposits is confined to the relief of pain by immobilization of the affected area, rest and deep X-ray therapy. Amputation of a limb may be justifiable if pain cannot be relieved by any less radical measure.

INDEX